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Progress at the Gatun Locks, Panama Canal

The 20 pairs of enormous steel gates necessary to operate the Gatun locks of the Panama Canal are fast nearing completion. The gate-moving mechanism has already been installed and tested on one pair of gates.

The illustration, Fig. 1, is taken from the center wall between the two lock chambers and looks north in the east chamber of the high-level locks. The gate leaf in the foreground is one of the upper guard gates; it is 58 ft. 4 in. high and weighs approximately 500 tons.

The second gates shown in the illustration are called the upper gates and are 77 ft. high, and each leaf weighs in the neighborhood of 700 tons.

The distance between the first two pairs of gates is 91.5 ft. Beyond these are seen the intermediate gates, which are also 77 ft. in height. The distance between these and the upper gates is 385.5 ft. It is in front of these intermediate gates that the first fender chain is placed. The distance to the farther end of the upper chamber, where the truss and locomotive crane are seen, is some 600 ft. from the intermediate gates, or something like 1100 ft. from where the photograph was taken.

FIG. 1. UPPER EAST CHAMBER OF THE GATUN LOCKS, PANAMA CANAL, SHOWING SOME 3500 TONS OF STEEL WORK IN PLACE
(Photograph by Underwood & Underwood, N. Y. City.)

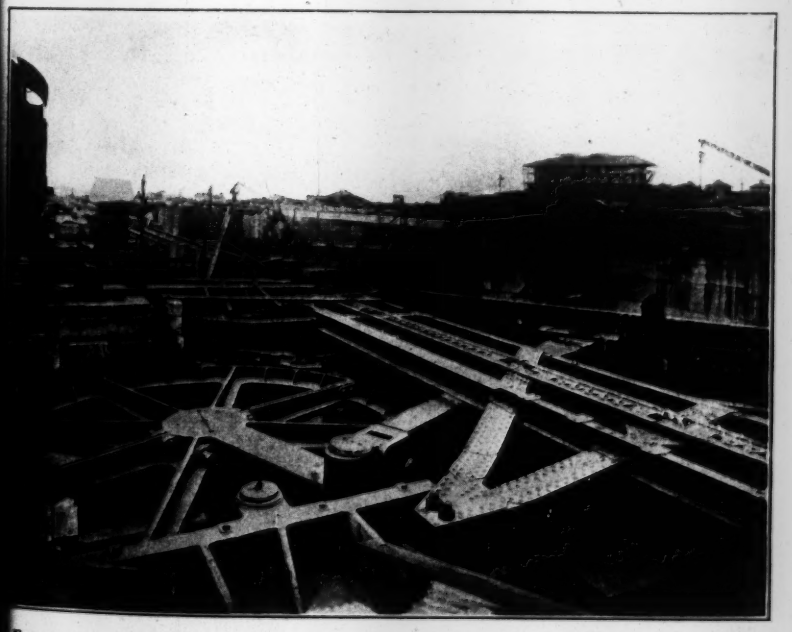


FIG. 2. GATE-OPERATING MACHINERY IN PLACE; GATUN LOCKS, PANAMA CANAL
(Photograph by Underwood & Underwood, N. Y. City.)

In the foreground of the picture, in the left-hand corner, is the steel framework which supports the gate-operating machinery. Fig. 2 shows this more in detail. Here is shown the great crank or "bull wheel," a combination gear and crank constructed of cast steel, 19 ft. 2 in. in diameter and weighing approximately 35,000 lb. This wheel turns through an arc of 197°, opening and closing the gate leaf by means of the steel strut or connecting-rod shown in the illustration. The connecting-rod is pivoted to the gate about 17 ft. from the hinge.

The bull wheel turns on a large center pin and is supported at the rim in four places by rollers. It is driven by a single pinion on a vertical shaft, shown in the picture near the crankpin. The vertical shaft is driven by a bevel gear and pinion, the pinion being fast on a horizontal shaft passing through the bulkhead which separates the motor chamber from the bull-wheel chamber. This

shaft carries a gear with spring center, which is driven by a pinion on the back shaft of an electric motor.

The strut pin is fastened on the bull wheel in a boss near the rim of the crank gear. The strut is a built-up structural member having a slip connection at either end, which allows the length of the strut to be changed within fixed limits. The slip joint is supported by a pair of rollers, which relieve it of undue bending strains.

To prevent excessive strains on the crank gear from wave action on the gate or other shocks, a spiral spring shock absorber is provided. This shock absorber is made of six nests of two springs each, and when solidly compressed exerts a pressure of 184,000 lb. It is assembled with an initial compression of 50,000 lb. The spiral springs are in compression for forces acting in either direction on the strut.

The crank of the bull wheel is so placed that the speed of moving the leaf is greatest when the gate is half open and diminishes in proportion to the nearness of the gate to its open or closed position. The whole operation of opening or closing the leaf was designed to require 2 min., but this time was cut in the first test made to 1 min. 48 sec., or 12 sec. faster than required by the contract.

A perfect miter is insured by means of a special device, which consists essentially of two box-shaped castings, one bolted to the outer end of the top girder of each gate leaf. One casting carries a pair of movable jaws and their operating mechanism, and the other has a large pin, which is inclosed by the jaws when they are in the closed position.

The jaws are connected by a series of toggle links to a crosshead nut, which is moved by means of a revolving screw. The end thrust of the screw is taken up by two thrust bearings which transmit thrust in either direction to the main-frame casting.

The screw is turned by a bevel gear in mesh with a bevel pinion on the motor-driving shaft, which passes through a plug bearing and is connected to the motor shaft by means of a friction cut-off coupling.

The forces acting on the jaws are transmitted directly to the frame through pins when the jaws are in locking position, and there is no strain on the screw due to forces acting on the jaws. When in open position the jaws allow either gate leaf to reach the mitering position without interference with the other.

The work of fabricating the Panama Canal lock gates was begun in Pittsburgh, Penn., the last week of October, 1910. The first shipment of the erecting plant arrived at the Isthmus in the first week of January, 1911, and the first week in May following saw the arrival of the first material for the gates themselves. The largest sections shipped weighed over 18 tons.

In just one year from the time the work of erection commenced, the first pair of gates shown in Fig. 1 had been erected, and the operating machinery installed and tested on one leaf.

The design of the lock gates was fully discussed in ENGINEERING NEWS of Sept. 16, 1909. The operating machinery is the invention of Edward Schildhauer, electrical and mechanical engineer in the office of the Assistant Chief Engineer, and is patented.

A 63-in. Gate under 148-ft. Head

In ENGINEERING NEWS, Dec. 28, 1911, the Adamello hydroelectric power development of the Società Generale Elettrica dell' Adamello, of Milan, Italy, was described. One of the notable features was an intake gate 63 in. square and withstanding a head of 148 ft., then noted as meriting further attention. Several inquiries have been made since the general article appeared, and the following notes on the gate have been secured from L. Zodel, Director of Escher-Wyss & Co., of Zurich, Switzerland, designers of the gate and other hydraulic works of the Adamello development.

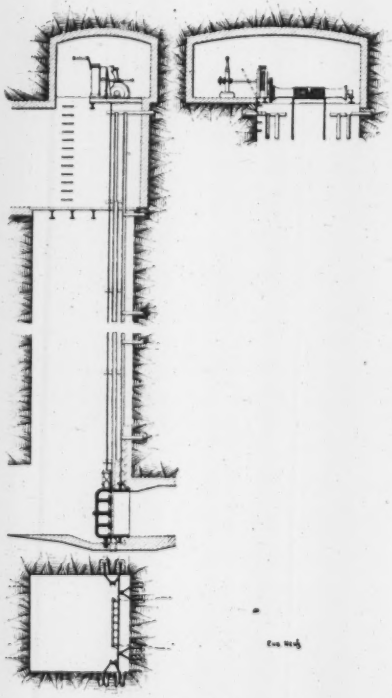


FIG. 1. SHAFT AND HOIST OF INTAKE SLUICE GATE; ISOLA PLANT

Water for the Isola plant is taken from a natural mountain reservoir, Lake Arno. There is a fall of 2985 ft. from the lake level to the hydraulic turbines.

In tapping the lake, which was [illegible] ft. 83 ft. below its natural level, a shaft, Fig. 1, was driven into the mountain side above the surface of the water, in the direction of the power plant, and a shaft was sunk to the level decided upon for the intake. Thence a tunnel, of circular section, was extended horizontally in both directions, first to the point where the pipe line begins and then to the lake, the latter section being completed after a sluice gate had been constructed.

It is this sluice gate which was built to be opened and closed under a pressure head of 148 ft. The gate is set in a frame 63 in. square, having the same area as the tunnel. The opening in the frame is covered by a box-shaped panel.

An ingenious construction, Fig. 2, was devised in order (1) to allow the gate to rest, when closed, with the full thrust of the water bearing on its wooden joint face, 5; (2) to insure a tight joint without risk of damage to the face through friction in raising, and (3) at the same time to do away with the considerable force which would otherwise be required to overcome that friction.

When the main cable, 6, is tightened, the coupled levers, 7, at the side of the sluice panel are lifted, and the eccentrics, 8, connected to them push forward a carrier, 9, which engages with the rollers, 10, and raises the gate panel off its seat, 11. The joint faces, 12 and 13, are now completely relieved and the panel is easily drawn up on its rollers, 10, which follow at half speed.

As soon as the tunnel opening is quite clear, the stationary suspension, 14, of the roller carriage, supported by the bracket, 15, on the wall, is engaged by notched plates fixed to the upper edge of the gate and is lifted. The roller carriage then travels up with the gate until both are above water level, or, if required, may be raised to the top of the shaft.

Exactly the reverse occurs when the sluice gate is lowered; the stationary suspensions of the two roller carriages remain in the notches of the wall brackets. The rollers then descend at half speed and the gate rolls on them as soon as the water thrust begins to act, until the lowest position is reached and the gate rests on its pedestal, 16. The side levers then fall into their lowest position by means of their own weight and by the thrust of the water pressure. The corresponding movement of the eccentrics lowers the gate from the roller carriage and throws the whole thrust on the joint face. The gate, with the roller carriage, travels loosely between the guide rails, 17, fixed in the shaft.

At the discharge end of the tunnel, about 295 ft. before its junction with the penstock, a vertical shaft has been cut through to the surface of the mountain slope above, 230 ft., to serve as a standpipe for taking up the pressure surges.

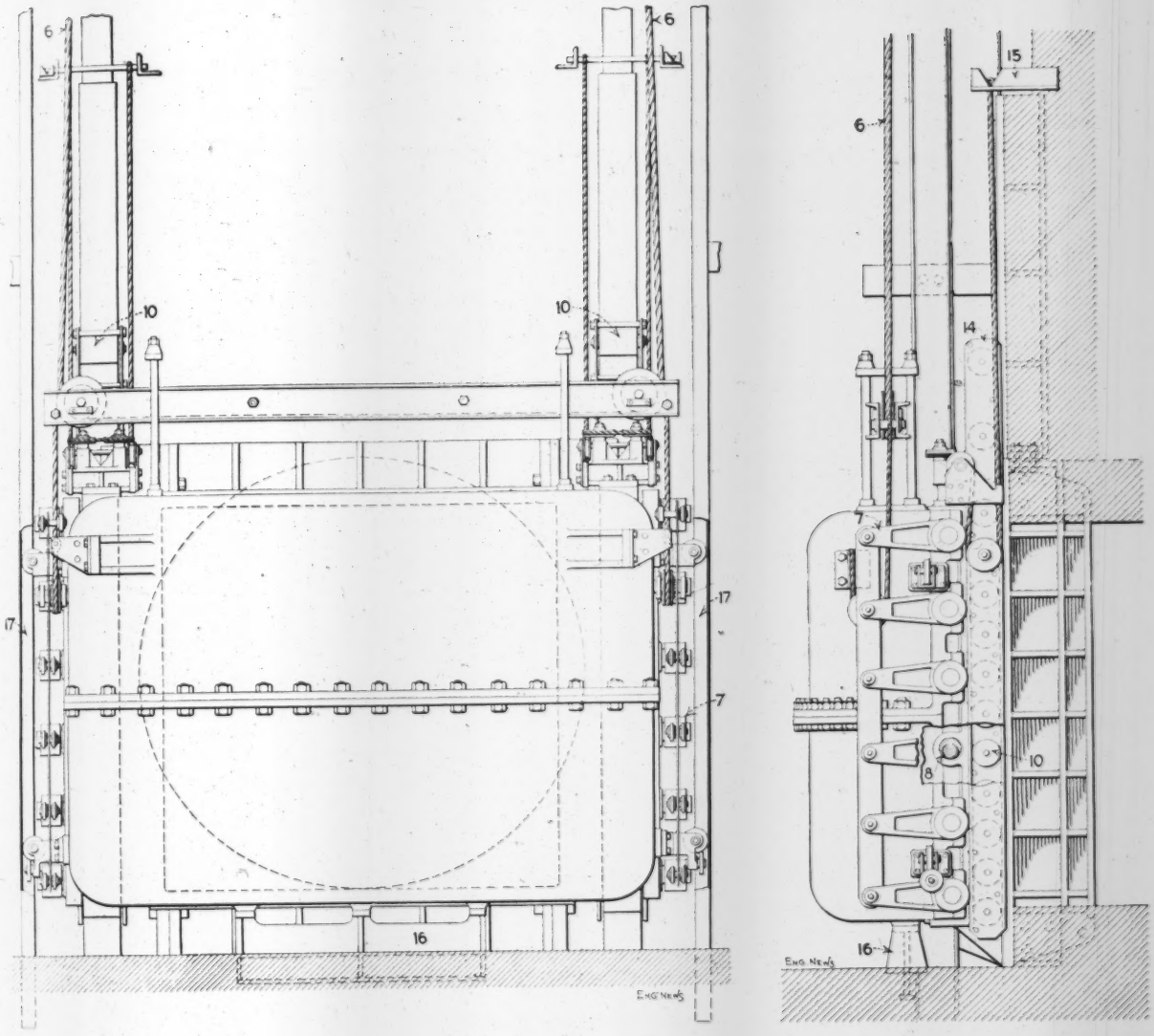


FIG. 2. ELEVATIONS OF SLUICE GATE; ISOLA PLANT INTAKE

It has a diameter of 23 ft. Both this and the sluice gate above described were planned with a view to the projected increase in the lake level, amounting to an additional 66 ft. of water, which will be effected by the building of a dam.

Twin Tunnels for Double Track will be built as part of the double-tracking work now in progress on the Denver & Rio Grande R.R. There are two short single-track tunnels in Price Cañon, Utah, on the work between Castle Gate and Kyune, and in order to avoid interference with traffic it is proposed to construct for the second track independent single-track tunnels at such a distance as to avoid any chance of injury to the present tunnels by the blasting on the new work. The double-tracking will include also several improvements in alignment and grade.

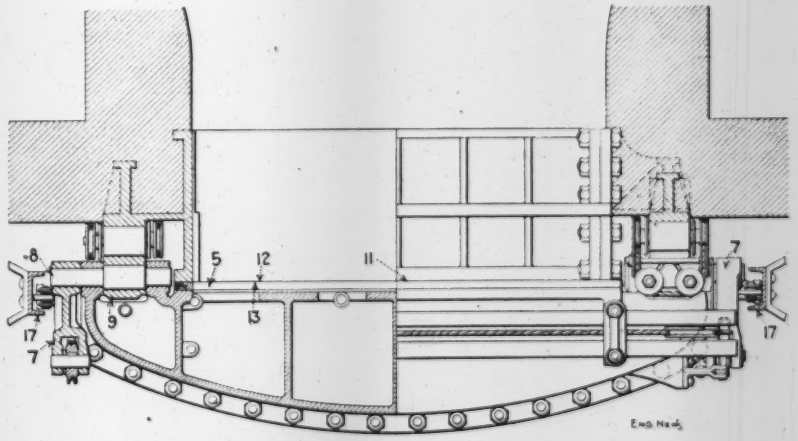


FIG. 3. SECTIONAL PLAN OF ISOLA INTAKE SLUICE GATE

Compensating Grades for Curvature

In railway location and in the tonnage rating of trains on lines with heavy grades an important factor to be considered is the extra train resistance due to curved track, and the compensation for this resistance which is introduced by reducing the grade on the curve below the normal grade on straight line. The question of this grade compensation for curves has been discussed by many writers on railway engineering, only one of whom (we believe) based his statements on experimental research, and these experiments are now long out of date. The practice on individual railways is diverse, and is based usually on personal opinion. The need of renewed experiments to determine a basis for grade compensation under modern conditions is pretty generally recognized, but nobody has yet undertaken to carry out such a line of investigation. In considering the subject it is important to review the statements of various authorities, but while this is evident, there are probably few engineers in active work who have the time or opportunity to pick out these statements from the numerous other subjects treated of in the books, and to compare or analyze these various statements. For this particular reason we have given in the present article a compilation of the statements of different writers and the actual practice of several railways. In an accompanying editorial, also, we have discussed the subject in general.

The subject of compensating grades on curves in order to offset the increased train resistance due to curvature crops up periodically, and it is evident that practice in this direction is not only very diverse but is based upon a very uncertain foundation. The subject is discussed in our editorial columns, and we present herewith a compilation of the statements and opinions expressed by different writers, quoting only those parts which are most directly pertinent to the subject.* It is mentioned in the early and noted "Shunk" and "Searles" field-books, the former giving a formula which is quoted below (by Mr. Beahan)†. In "Field Engineering" (1887), by W. H. Searles, the curve resistance (lb. per ton) on a curve of given degree is stated as $0.56 \times D$, while the grade (per cent.) on tangent having the same resistance as the given curve is stated as $0.025 \times D$. Thus the resistance and compensation were assumed to vary directly with the degree of curve, which is now almost universally recognized to give incorrect results. On the subject of compensation, Mr. Searles stated as follows:

"In locating a road, the maximum grade should be reduced on a curve by the amount of the equivalent grade of the curve [see formula above.—EDITOR.] so that the resistance may be no greater on the curve than elsewhere. But grades less than the maximum need not be reduced for the curves upon them, unless the sum of the grade and the grade equivalent exceeds the maximum."

A. M. WELLINGTON

The most extensive analysis (and we might say the only thorough analysis) of the subject is that given in Wellington's "Economic Theory of the Location of Railways" (1887), and we recommend a careful study of the exposition there given, with the reservation that the reader should remember that the conclusions may not apply directly under modern conditions of rolling stock and traffic. As a compilation of opinions on the subject would be incomplete without some outline of those of Mr. Wellington, we give below a few extracts, together with his summary of conclusions:

Under three different conditions curvature may come (in advance of gradients) as a limiting agent to fix the weight of trains:

1. When curves are introduced on a maximum grade without reducing the rate of the latter by compensation for curvature, so as to keep the aggregate resistance constant on both curves and tangents. 2. When a line is nearly or quite level, and yet runs through a region requiring curvature which (as is very apt to happen on such lines) cannot be "compensated" because there are no grades, or no sufficiently high grades to reduce, in order to eliminate their additional resistance. 3. When on lines of the latter (or any other) class curvature of such short radius is used as to limit the length of trains more than would the same amount of curvature with longer radii. These causes are more or less interrelated.

The proper rate of compensation is not a fixed quantity, but may under varying circumstances vary within somewhat wide limits. The more usual rates are from 0.03 to 0.05% per degree of curvature, corresponding to 0.06 to 1.0 lb. per ton per degree. If the precise amount of curve resistance were known, and if it were always the same, of course but one rate of compensation would be proper, but as its precise rate is not known, and as there is strong reason to believe that in starting a train it may possibly amount to as much as 2 lb. per ton, a compensation sufficient to equalize curve resistance in ordinary circumstances cannot be assumed to be certainly sufficient at points where speed may be expected to be very slow, as toward the top of long grades and occasionally at other points.

Under these circumstances, prudence would indicate that wherever there is no physical limit to the possible reduction of grade on curves, it should be made ample, so that the curves should certainly offer no greater resistance than the adjacent tangents. At stations this rule would require a grade reduction of 0.1% per degree.

On the other hand, when we are merely trying to equalize the tangent and curve resistance on a long ascent, and whatever is taken off the curves must be added on to the tangents, no such practice is proper. If we come as near to an exact equality as we can, in compensating for curvature, it is of no importance whether our compensation is a little too great or a little too small. In the one case trains will stall on the tangents and in the other on the curves; that is all. Our object is simply to guard against a certainty of stalling on either. Nothing more than this is important.

Hence it may well be that on a long and crooked ascent, where the curvature greatly exceeds the tangents, yet where there are one or two considerable tangents, prudence will require the assumption of a very low rate of compensation; for otherwise a very slight loss of elevation on each curve, multiplied by many curves, will prevent our attaining the desired summit without a considerable increase of the normal tangent grade. If we have guessed right as to the real curve resistance, this may do no harm; but, on the other hand, if we have guessed wrongly, and exaggerated the probable curve resistance, we shall have unnecessarily increased our tangent grade. Hence, by assuring a low rate of curve resistance in such a case, we can hardly in any case lose anything appreciable, and may save a needless loss of grade. A compensation rate of 0.03% per degree of curvature may then be proper, below which the rate of compensation should never fall.

For the same reasons, it may well happen that at different points on the same line different rates of compensation may be proper. Where the loss of elevation by a high rate of compensation is a very serious matter, because of a great amount of curvature, it may be taken at a minimum. At other points, where there is less curvature to be compensated and a higher compensation can be had at little or no cost, it should there be used. The effect will be to make most of the maximum grade scattered over the division a little easier to handle trains on than the longest or worst grade. This may well result in handling a car or two more than would be deemed possible were the resistance as great at two or three points as it is at one.

It is always worth while to keep a little below the maximum where possible, at moderate cost. This is only another application of the same principle, but, owing to the uncertainty which hangs about the question of curve resistance, it is a wiser way of attaining the same end than to reduce the nominal tangent grade, especially in the vicinity of stations.

CONCLUSIONS—1. With short grades or under favoring topographical conditions compensate as liberally as possible.

*See also a discussion on this subject in Engineering News, Apr. 16 and June 11, 1908.

†See quotation further on from a modern edition of Shunk's field book.

up to a maximum at special points of 0.10% per degree.

2. Where speed may sometimes be very low, and hence invariably on or very near to known stopping places, this maximum rate appears, with our present knowledge, none too much. In general, however, 0.05% per degree (= 1 lb. per ton) is an ample equivalent for curve resistance, and for fast trains alone probably 0.02 to 0.03% (= 0.4 to 0.6 lb. per ton) is sufficient to balance the resistance.

3. On sections where curves largely predominate over tangents it is particularly desirable to have ample compensation, and, if excessive, it will do least harm.

4. On sections where the amount of curvature is small it is less important to have full compensation, and if excessive it will do most harm.

5. When the rate of compensation can only be increased at the certain cost of a corresponding increase in the rate of tangent grades (making very sure that it is certain, and not an over-hasty conclusion from inexperience or lack of care), no larger rate than we feel practically certain will be required to balance the curve resistance (0.03 to 0.04) should be chosen. Otherwise, we are committing the folly of making a certain addition to the grade in one place, to avoid one in another place which is merely problematical.

6. On any minor gradients where the curvature is not sufficient to bring the virtual profile up to the maximum it is not important to compensate for curvature at all, although it is generally as well to do so, especially at points where to do so will slightly reduce the cost of construction, as is very apt to be the case on long curves. When not compensated, the curvature merely has an equivalent effect to a slight undulation of gradient, which produces no shock to the train and so is not a measurable disadvantage.

7. It is not in the least essential or important to precisely adapt the compensation to the exact length of each curve. The reduced rate may as well as not begin and end at the nearest even station, and may be made a little less on one curve and a little more on one immediately above if a horizontal slice of a foot or more may thereby be taken off a high fill on the tangent connecting them, but never so as to cause the grade to rise above the uniform grade line.

8. Curves immediately below a known stopping place for all trains need not and should not be compensated at all.

9. The rate of compensation should be uniform per degree for all degrees of curvature, or in no case made greater for the sharper cuves. It may even be made less for curves of over 10°. If the rate be reduced one-half for the excess over 10°, making the compensation for a 16° curve thirteen times that for a 1° curve, it will certainly lead to no bad results, although a rather rough rule. This is directly contrary to the usual practice, which is to increase the rate of compensation with the sharpness of the curve, if anything; but this practice rests upon the assumption (which is the direct contrary of the truth) that the curve resistance increases with the degree of the curve. The results of experience on the New York elevated lines and numerous others with very sharp curves, both of standard and narrow gage, is enough to disprove this, confirmed as it is very directly by the indications of theory.

10. Since there is no reason to believe that curve resistance increases per ton with the length of the train, or even (appreciably) with the type of engine, there is no reason for varying the compensation because of the grades or length of train, except that it is usually easier to spare the elevation for a liberal rate of compensation, with low grades than with high ones. It is, therefore, proper to do so.

W. Beahan

This author states as follows in his "Field Practice of Railway Location" (1909):

"In laying the grade line on the location profile, the rate of maximum grade per station must be reduced by such an amount as necessary to compensate for resistance due to curvature. The reduction in gradient formerly* was 0.05 ft. per station of 100 ft. for each degree of curvature. If the maximum gradient was 1%, then a 20° curve would have to be level. As this rate was established by trial of locomotives it varied on different roads. Shunk's formula for equating gradient for curvature was: Degree of curvature (squared) + 10 times degree of curvature ÷ 500. This gives the reduction in grade per 100 ft. and gives an 18° curve as being level when the maximum grade is 1%†. The amount of curvature, 5° and flatter, that exists in America on unreduced maximum gradients is enormous. The equating of curvature remains in use as it is based on observed fact."

A. M. Haynes

In his "Curves of Civil Engineering" (1903), this author gives a table of compensation for curves on maximum grades, in which the rate of compensation per degree decreases from 0.03% for a 1° curve to 0.02% for 20°. The total compensation then ranges from 0.03% for 1° to 0.1% for 3½°, 0.2% for 8°, 0.34% for 15° and 0.4% for 20°. This idea of decrease in rate of compensation with increase in degree of curve is suggested by Wellington and also later by Raymond and Webb (as noted below), while some writers have advocated an increase in rate of compensation with the increase in degree of curve. On this subject Mr. Haynes states his views as follows:

"When laying a maximum grade or where uniform resistance is desired, the rate of grade should be made less on curves than on tangents by the amounts shown in the table [noted above.—Editor.]. In the lower portions of a maximum grade, where high velocities are admissible and can be had, compensation for curvature is unnecessary. But where the velocity may fall to 8 m.p.h., curve resistance should be compensated fully in the grade so that the resistance and velocity will be uniform. If the velocity drops so that the centrifugal force is lost, the train stalls. A maximum grade in a district is not necessarily one of maximum ratio, but one which produces a maximum tractive power, where curves and velocity are considered."

F. Lavis

From "Railroad Location Surveys and Estimates" (1906), we take the following extracts relative to grade compensation on curves, but omitting portions which relate to the ultimate effect of such compensation upon the profile and the operating conditions:

As the resistance to the passage of trains is greater on curves than on tangents, this varying directly with the degree of curve (or, in other words, with the radius), the ruling grade used on tangents must be lessened on the curves, so that the combined resistance due to the curve and the grade on the curve will not be greater than the resistance of the grade alone on the tangents.

Owing to varying conditions of track and rolling stock, the compensation necessary cannot be determined exactly, but is ordinarily assumed to be about 0.04% per degree of curve; that is to say, with a maximum grade of 0.6% on tangents, a 4° curve, for instance, should not have a heavier grade than 0.6 — (4.0 × 0.04) = 0.44%. The amount of compensation for curvature is assumed usually to be the same per degree for any degree of curve; thus, if it be assumed at 0.04% per degree, a 1° curve would be compensated 0.04 per station and a 6° curve 0.24 per station. It is generally conceded, however, that the resistance due to curvature does not increase proportionately as the degree of curve, and the writer prefers to use a sliding scale somewhat as follows: Curves up to 2°, 0.6% per degree; 0.05% to 4°, 0.04% to 8°, and 0.03% per degree to 14°. This is intended only as an approximation and suggestion.

The proper amount of compensation for curves is a matter on which opinions vary, and which varies with the state of the track, type of engines, etc. Where curves are few, and, therefore, probably of large radius, the compensation can be increased to as much as 0.1% per degree, with little probability of increasing the cost of construction, and any error surely will be on the right side. On long ascents, where often every inch counts, and where often a high rate of compensation will mean a higher rate of grade on tangents, or a much longer line, compensation as low as 0.03% for all curves will probably be sufficient. It will be seen that a most important point in locating long lines on ruling grades is the avoidance of curvature as far as possible. More curvature means less rate of grade and, therefore, longer line.

Where possible, grades should always be compensated for curvature, whether they are maximum grades or not; provided, however, that such compensation of grades is less than the maximum does not unduly affect the cost. The ideal line from the operative standpoint, as regards fuel economy, and to a certain extent the wear and tear on rolling stock, is one where the differences in resistance due to varying curves and rates of grades are reduced to a minimum. In other words, where, with a constant head of steam, the throttle can be set at a certain point and the train

*The same statement is made in the 1906 edition of Mr. Beahan's book, but he does not explain what period is referred to by the term "formerly."

†See quotation further on from a modern edition of Shunk's field book.

will pull just the same all the way. [For momentum grades] curvature on the maximum grade, when this is greater than the ruling grade, must, of course, be compensated the same as elsewhere, though probably a little more liberally; and in calculating the length of the momentum grades the entire resistance of the curvature must be taken into consideration.

Compensation for curves should be from the nearest even station to the ends, and where spirals or easements are introduced this may generally be from the ends of the true curve (that is, the true curve from the offset points, including the whole central angle), except where the spirals may be very long and then an average rate for the spiral may be introduced.

L. B. MERRIAM

The subject was under discussion some ten years ago in ENGINEERING NEWS, and in our issue of Sept. 5, 1901, Mr. Merriam stated his opinion as follows:

"The compensation for curvature should be on a sliding scale, beginning with about 0.04%, or 0.03% per degree, and decreasing as the degree of curvature increases. All the experimental data I have been able to gather confirm this conclusion, but as the condition of the rail with regard to wear enters so largely into this proposition, the results do not point to any definite formula for compensation. The general tendency of modern practice is in the direction of lower compensation all along the line, one prominent western road with easy curves uses only 0.02% per degree."

In commenting upon this, J. L. Campbell stated that he thought it rather doubtful practice to adopt lower rates of compensation on sharp curves, for, while they will give a lower resistance per degree when new rails are laid, the latter soon give increased resistance through greater wear, more nearly proportional to the degree of curve. He considered that the tendency toward lower rates on sharp curves was due more largely to the great loss of elevation entailed by a proper compensation. However, as noted elsewhere, the analysis of the subject supports the views in favor of lower rates for sharper curves. Following up this matter, we wrote Mr. Merriam recently in regard to his letter quoted above, and his reply is as follows:

"The recent discussion of this subject before the American Railway Engineering Association [noted below.—EDITOR.] was centered around a rate of compensation of about 0.03%. The reason for the statement I made ten years ago was this: in going over a carefully built railway while it was in perfect shape, where the track has been put up to top of rail stakes with an exactness unusual even in well built roads, and where the compensation was uniform, heavy trains which barely maintained speed on maximum grades on tangent, gained speed on curves; all curves had the same compensation, and more speed was gained on 6° curves than on 2° curves. I have never had the opportunity to measure the resistance due to curvature, but believe the observations above mentioned were carefully taken. They were repeated a number of times and were confirmed by the trainmen operating on the districts where the most curvature existed.

"The condition of the rail is of such importance in this connection that it will be well to state that the rail was new when the above observations were made. The rapid wear of rails would seem to be an argument against the position stated by me in 1901, but Wellington's conclusions regarding rail wear indicate a wear proportional to the degree of curvature. This being true, the increase in surface of contact would be less, after a short time, in sharp curves than in easy curves. Rail maintenance would seem to be one of the conditions required to be known before the rate of compensation can be fixed for any given line, and as this is very hard to forecast, I am using 0.03% in my own practice."

W. G. RAYMOND

The following is from "Elements of Railroad Engineering" (1909):

"It is customary to offset curve resistance on heavy grades, and on all grades where the combination of curve resistances and grade resistance would more than equal the grade resistance of the ruling grade of the road or division, by reducing the grade. On a crooked road of light grades, curve compensation is impracticable, the curves being in effect the ruling grades. The usual allowance is 0.04 to 0.05% per degree of curvature. But it is thought that on good track 0.025% will be sufficient for 5° curves. The compensation, however, should vary with the degree of curve, and the following values are suggested: 1°, 0.04%; 2 to 4°, 0.03%; 5° and over, 0.025%. When there is no necessity to save in gradient, full compensation (even up to 0.05%) can do no harm. With poor track and badly curved rails, compensation should be high."

W. F. SHUNK

A formula given by Shunk has been mentioned already (in the quotation from W. Beahan), but we do not find this in the 1902 edition of Shunk's "Field Engineer." The subject of grade compensation for curvature is there covered by the following statement favoring a high degree of compensation:

"It is a good custom, and one which cannot prudently be neglected where long stretches of maximum gradient are encountered, to 'slacken grade' on the curves. Opinions differ as to the right allowance per degree of curvature, and no experiments seem to have been made from which to deduce an authoritative rule. Some say 0.025% per degree; others, 0.05; others, variously between the two. Probably 0.05 is the safe rule. This amounts to 2.64 ft. on a mile of continuous 1° curve, and makes a 6° curve about the curve of double resistance at ordinary passenger speeds."

E. E. R. TRATMAN

The following extract is from "Railway Track and Track Work" (1908), and is accompanied by figures of the practice on several railways (see table 1, on p. 281), showing that at that time the ordinary rate was 0.03 to 0.04%, with special rates near stopping places, and sometimes a special compensation in tunnels (to offset decreased adhesion due to damp or slippery rails):

"When curves occur on heavy grades, the grade should be so reduced that the combined train resistance due to grade and curve will not exceed that due to the maximum grade allowed on the tangent. This reduction is taken variously at 0.03 to 0.05% per degree of curve. Thus, with a maximum grade of 2% on tangent, and a rate of compensation of 0.04%, the maximum grade on a 6° curve would be 1.76%. The amount of elevation lost by compensating the grade is found by multiplying the degree of central angle of the curve by the rate of compensation; and this elevation divided by the length of grade will give the rate by which the maximum grade on tangent must be increased to avoid a final loss in elevation.

"The change in grade may commence at the nearest even station, and not necessarily at the P. C. The reduced grade extends usually beyond the curve. To avoid too great a loss in elevation or too heavy a grade on the tangent, it may be necessary to modify the rate of compensation, but this will depend largely upon traffic conditions. In general, the compensation should be introduced even upon easy grades, especially those which approach the rate of ruling grade, in order to provide for future increase in train loads or reductions in grades. For curves of 10° or over, the rate of compensation may be reduced (as curve resistance does not increase with the degree of curve). There is a great diversity of practice, which is based largely upon opinion and experience, and there is much need for careful experiments in order to give some definite knowledge as to the requirements under modern conditions of rolling-stock and traffic."

W. L. WEBB

The following quotation is from Webb's "Railway Construction" (1909):

On minor grades the addition [of resistance due to curvature] is of little importance, but when the grade is nearly or quite the ruling grade of the road, then the additional resistance induced by a curve will make that curve a place of maximum resistance, and the real maximum will be a virtual grade some-

what higher than the nominal maximum.

The proper rate of compensation evidently is the rate of grade of which the resistance just equals the resistance due to the curve. But such resistance is variable. It is greater as the velocity is lower; it is generally about 2 lb. per ton (equal to a grade of 0.1%) per degree of curve when starting a train. On this account the compensation for a curve which occurs at a known stopping place for the heaviest trains should be 0.1% per degree of curve. The resistance is not even strictly proportioned to the degree of curvature, although it is usually considered to be so. On this account the compensation per degree of curve may be made less on a sharp curve than on an easy curve. The compensation actually required for very fast trains is less than for slow trains, say 0.02 or 0.03% per degree of curve. But since the comparatively slow and heavy freight trains are the trains which are chiefly limited by the ruling grade, the compensation would be made with respect to those trains. From 0.04 to 0.05% per degree is the rate of compensation most usually employed for average conditions.

1. On the upper side of a stopping place for the heaviest trains, compensate 0.10% per degree of curvature.

2. On the lower side of such a stopping place do not compensate at all.

3. Ordinarily compensate about 0.05% per degree of curve.

4. Reduce this rate to 0.04 or even 0.03% if the grade on tangents must be increased to reach the required summit.

5. Reduce the rate somewhat for curvature above 8 or 10°.

6. Curves on minor grades need not be compensated, unless the minor grade is so heavy that the added resistance of the curve would make the total resistance greater than that of the ruling grade, or unless there is some ground to believe that the ruling grade may be reduced some time below that of the minor grade under consideration.

American Railway Engineering Association

This association, through its standing committees, has given a considerable amount of attention to this subject. It is to be noted that the committees which have reported upon it have been of a rather exceptionally high character as to the members and their work, and for this reason their statements deserve careful consideration. Extracts from the several reports, covering practically all that is said on this particular subject, are given below:

1901—In connection with a complete change of location or a modification of the existing location, the maximum grade and curvature should be decided and the necessary compensation calculated for the curves, to make the resistance on curves equal to that on a straight line. On lines where tests have been carried out on an extensive scale, it has been found that it is good practice to use 0.03% for each degree of curvature for all curves up to and including 2°, and 0.04% above that to 4°. (Committee on Grading.)

1902—From the result of the committee's inquiries it would seem that the practice in this country at present favors compensation proportioned to degree of curve, and 0.04% per degree represents average practice. The observation of the effect of compensation, however, seems on the whole not to have been critical enough to determine definitely whether or not it should be proportional to the degree of curve, and further experiment and critical observation are needed. The effect of curves, as shown on a speed recorder capable of recording slight changes in speed, is suggested as a desirable method of experimenting*. (Committee on Roadway.)

1907—Curve resistance is estimated by different engineers at different values. The compilation made by the Committee on Roadway (1902), showed that 0.8 lb. per ton per degree on central angle, or 0.04% for compensation per degree, well represented average practice (Committee on Economics of Railway Location).

1908.—An inquiry was made by the above committee as to whether any experiments had been made in recent years which confirm or modify the commonly accepted value of 0.04% per degree of curve as the rate of compensation for curvature. Although independent experimental work was referred to, many of the answers merely stated the practice regarding curve compensation. There was a remarkable amount of unanimity in saying that 0.04% was a little higher than necessary, that 0.03% was too small and that 0.035% seemed the proper figure. The variations ranged from 0.02 to 0.08%. In investigating the accuracy of allowance for compensation, the widening of gage on curves should be tested.

1910—We are interested in curve resistance chiefly from the standpoint of its compensation. In the location of a railway, curvature evils may be eliminated partially by reducing grade on the curve by such an amount as to make the engine effort the same on curve as on tangent. Tests made on the Baltimore & Ohio R.R. (1904), show that on the portion compensated 0.03%, the resistance on curve was greater than on tangent, and on the portion compensated 0.04% the resistance on curve was less than on tangent. In replies to a circular sent out in 1907, the consensus of opinion was that 0.035% per degree gave the best results (Committee on Economics of Railway Location).

The committee's recommendation, as adopted by the Association, reads: "In order to equalize resistance on curve and tangent, curves ordinarily should be compensated 0.035% per degree of curvature. The effect of curve resistance is dispelled more slowly at slow speed than at high speed."

In the discussion, some of the speakers proposed to substitute 0.04%. Further it was pointed out (following the Wellington line of reasoning) that the rate of compensation should never be made absolutely constant, as the effect of the compensation on construction and on the ruling grade should be taken into account. In some places a high rate of compensation can be introduced without harm; but in other cases the rate has an important influence upon the cost of construction. To adopt as standard a rate that is excessive for average conditions means waste of money and improper compensation. It was with this idea also that the meeting added the word "ordinarily" to the recommendation as originally formulated. It was suggested also in the discussion that on a line built exclusively for freight service, and having curves superelevated for low speed, 0.03% will be to much. The Committee's report was accompanied by a table representing actual practice on different roads. This is given herewith, supplemented by figures from Tratman's "Railway Track and Track Work".

RAILWAY PRACTICE AS TO GRADE COMPENSATION FOR CURVES

N. Y., N. H. & H.	0.03 too light, 0.04 too heavy.
B. & O.	0.03 too light, 0.04 too heavy.
So. Pac. (At. Sys.)	0.03 too light, 0.04 too heavy.
*No. Pac.	0.03 too light; 0.04 fairly good results (not quite enough with curves frequently changing direction, slightly in excess for long continuous curves)
C., R. I. & P.	On 0.03 (with new rail) trains retarded at less than 10 m.p.h. and accelerated at higher velocities.
G. T. Pacific	0.04 too high for new rail.
N. Y. Central	0.03 made limiting grades on curves; 0.04 satisfactory.
*C., M. & St. P.	0.035 generally on maximum grades; sometimes 0.03.
P. & L. E.	0.035 satisfactory.
Erie	0.035 satisfactory.
N. & W.	0.035 satisfactory; trains accelerate on 0.04.
Car., C. & O.	Trains loaded for 1% grade accelerate on curves compensated 0.035.
*L. & N.	0.03 too low; 0.05 to be used.
W. & L. E.	0.03 used, but 0.04 preferred.
Can. Pac.	0.04 satisfactory up to 5°; too high for sharper curves.
Wes. Pac.	0.04 used, but probably higher than necessary.
Wash. & Ore.	Trains stalled or retarded on 0.04; 0.05 satisfactory. On 0.05 trains loaded for 10 m.p.h. on ruling grade tangents retarded; trains for 15 m.p.h. accelerated.
*Ill. Cen.	0.04. On Ind. So., 0.04 when curve was as long as maximum train, 0.03 when not more than half as long as train.
*Ph. & Read.	0.04.

*From Tratman's "Railway Track and Track Work."

*It may be noted that a recent writer, quoted elsewhere, does not think that speed recorders are sufficiently sensitive or accurate for this purpose.—Editor.

A Record Breaking Train of empty coal cars was hauled westward on the Lehigh Valley R.R. from Perth Amboy, N. J., to the Mahoning yards in Pennsylvania, on Aug. 1. The train was composed of 133 cars, drawn by two locomotives with a third pushing; it was 7000 ft., or about a mile and a quarter long.

State Highways in Massachusetts*

By Arthur W. Dean†

Massachusetts was the first state to establish a Highway Commission, and for 20 years its highway engineers have been regarded as authorities on road construction. This article is a resumé of these 20 years' experience in the construction and maintenance of broken stone and gravel roads under changing conditions in the character of traffic. What Massachusetts has accomplished by an average annual expenditure of only $500,000.

*Paper read before Boston Society of Civil Engineers, May 15, 1912; abstract from "Journal of the Association of Engineering Societies" for July, 1912.

†Chief Engineer, Massachusetts Highway Commission, Boston, Mass.

The present year marks the 20th anniversary of legislation leading to state control of highways in Massachusetts. Under an act passed in 1893 appropriations for the construction of roads have amounted to $9,500,000.

During the first year that an appropriation was available, that is, in 1894, about 40 miles of road were laid out as state highways, and constructed or contracted for. At the end of the fiscal year 1911, there were 879.6 miles of state highways constructed.

EARLY EXPERIENCE IN MAINTENANCE—The earlier roads built were nearly all of the macadam type. A few gravel roads were constructed, however, in localities where an excellent quality of gravel could be obtained. The roads were all very thoroughly constructed, much attention being paid to proper foundations and to both ground and surface drainage. The maintenance of these roads, thoroughly and properly constructed as they were, was a very minor problem until the advent of the motor vehicle.

To one who is constantly facing the maintenance problem at the present time, it is somewhat amusing to note reports made early in the last decade by engineers, in which they appeared to hesitate in recommending surface repairs costing at the rate of $200 per mile, apologizing for as well as explaining the request for such a large amount of money.

Until the year 1906, no special treatment was thought of or required for the maintenance of the average macadam state road, except to keep the surface properly bound with stone dust or sand. In 1906, the Commission noted that motor vehicles appeared to remove the binding material from the upper surface of the road and cause raveling. In that year it was not looked upon very seriously, but the following year it was noted quite carefully and experiments were made with surface treatment of the macadam roads with tar. During that year about 7½ miles of macadam road received surface treatment, and since that time about 550 miles have been treated with tar or asphalt, either in construction or by surface treatment.

While the first bituminous treatment of any extent was applied in 1907, that was not the first year in which oil was used by the Commission for surface treatment of roads. In the year 1899, the railroads were using oil to a certain extent as a dust preventive on their roadbeds, and an experiment was tried in Cottage City, using a so called "roadbed oil" as a dust layer. This oil was very effective as a dust layer for a short time, but after about a month the effect of the oil disappeared and the road upon which it had been used began to ravel, and thereafter for several years was maintained as previously by using stone dust or sand as a surface binder.

ESSENTIALS OF GOOD CONSTRUCTION—In contemplating the construction of a road, the first thing considered is a proper location, with reference to grade and alignment. The conditions in Massachusetts are such that a very large percentage of the State highways necessarily follow existing roads. Surveys and studies are made, however, in order to secure the best grades and alignment possible under the limitations imposed by local conditions.

The next consideration is the drainage and foundation. This subject, having been referred to so many times by various writers, would seem to need little comment at this time, except, however, to affirm that no matter how good and permanent a road surface is to be constructed, proper drainage, foundation and subgrade are just as essential as in the construction of the old form of macadam and gravel roads; in fact, if any distinction is to be made, more attention should be paid to drainage and foundation on account of the fact that if a modern road breaks up on account of improper subgrade construction, the expense of repairing the road is greater, consequently more care should be exercised in preparing for the modern surface.

THE TYPE OF SURFACE—This will be dependent upon the nature and amount of traffic to be supported, and upon the grades at which the road is to be constructed. In considering traffic, the fact should not be overlooked that the construction of a new and perfect surface over a proposed route may lead to the deviation of traffic over that route, consequently increasing it greatly above the traffic existing previously to the construction of the road.

Many motor enthusiasts now predict that the days of horse-drawn vehicles are numbered, yet the time when horse-drawn vehicles may entirely disappear is surely sufficiently distant that they must be considered at the present time in connection with the type of road surface to be selected, particularly on steep grades. A smooth pavement may be permissible on level grades or on roads with a slight grade, but the per cent. of grade should receive serious consideration before determining the type of surface to be adopted.

The conclusion has been reached that in most localities the traffic in such that it is not economical construction to build an ordinary water-bound macadam road and immediately treat it with a surface application of bitumen. While the cost of building a road under this method is only about 8c. per sq.yd. greater than the cost of building an ordinary water-bound macadam road, the result is not commensurate with the additional expense, and is not economical as compared with roads in which the voids in the upper surface are entirely filled with a bituminous material, the expense of this latter treatment being only about 20c. per sq.yd. greater than the cost of the ordinary water-bound macadam surface.

Experience up to the present time appears to warrant the construction of state roads on general through routes by this latter method, that is, by incorporating the bituminous binder in the upper 2 in. of the surface of the macadam.

ASPHALTIC OIL BINDER—A method used quite generally this year is as follows: After the subgrade has been properly prepared, broken stone varying in size from 1¼ to 2½ in. is spread to a uniform thickness varying somewhat with the nature of the anticipated traffic, and dependent also upon the quality of the subgrade. If the subgrade is of excellent gravel, a thinner layer may be used in the bottom course than would be used if the subgrade is of poorer material. The most common thickness of this first course is 3 in. after rolling. This course is thoroughly rolled, the voids being entirely filled with stone dust or other suitable material.

After this course has been thoroughly compacted, any dust or dirt that may be left on top is cleaned off, and asphaltic oil applied, using for this application ⅝ gal. per sq.yd. of 90% asphalt oil, the application being made while the oil is at a suitable temperature, varying according to the viscosity of the material from 175°

to 225° F. Immediately after this oil is applied, stone varying from ½ to 1¼ in. in diameter is spread over the oil, the stone having previously been distributed in piles along the side of the road.

The thickness of this stone layer should be fairly uniform and should be such that it will roll to about 1½ in. After a partial rolling of this course, a second application of oil is made at the rate of ⅝ gal. per sq.yd., and it is then lightly covered with additional stone of the same size, after which a third application of oil is made at the rate of about ¼ gal. per sq.yd., this oil being immediately covered with clean ½-in. screenings, thoroughly watered and rolled.

The entire quantity of oil used, when the stone to be bound does not exceed 2 in. in thickness after rolling, should never exceed 1½ gal. per sq.yd. Much better results appear to be obtained when water is used before applying the oil in each instance, and during the final rolling of the screenings. It is probable that the alkali in the stone assists in forming an emulsion of water and oil which permits the asphalt to adhere to every part of the surface of the stone.

This type of surface has been built successfully during the past two years, giving apparently such good results that, considering the expense, it may be considered as very economical construction for rural highways. It has been demonstrated that the actual cost of such construction above the cost of the ordinary water-bound macadam road, the price of the oil being 6½c. per gal. f.o.b. cars, within two miles of the work, is not more than 20c. per sq.yd. The average cost of the ordinary water-bound macadam surface is 60c. per sq.yd., or $5280 per mile of road 15 ft. in width. The additional cost of the top surface of the road described above, namely, 20c. per sq.yd., would make such a road cost 80c. per sq.yd., or $7040 per mile.

The cost of maintaining such a road will vary with the traffic, but at this time such roads have not been built for a sufficient length of time to permit positive statement of the average annual cost of maintenance. Under ordinary traffic, however, on rural roads, it is probable that such a road built with proper asphaltic material will require a surface treatment about once in five years, such treatment costing about 10c. per sq.yd., making the average annual cost of surface maintenance 2c. per sq.yd., or $176 per mile per annum.

Tar Binder — Roads under similar traffic conditions have been constructed in a few instances, using the same method for the foundations and bottom course of stone as described above, but using tar as a binder instead of heavy asphalt oil. Ordinarily where the tar is used as a binder, it is used in one application of approximately 1½ gal. per sq.yd. on top of the second course of stone. Some expense is saved in the first cost of a road built with tar in that it saves a second handling of the stone in the second course, this second course being spread as in an ordinary water-bound macadam road, and after it has been partially compacted by rolling, refined tar is applied by a pressure distributor, followed by an application of ½-in. screenings, the whole being then thoroughly rolled and compacted.

The reason for the difference in method of applying the oil and tar is that oil penetrates upward as well as downward, whereas tar has a tendency to penetrate largely downward. Tar has not been used very extensively by the Commission for the reason that tar appears to disintegrate under atmospheric action much more rapidly than asphalt products; this disintegration may be prevented, however, and the life of the material prolonged by applying annually a thin surface coating of refined tar.

Natural Asphalt Binder—A few of the roads controlled by the Commission have such a heavy and varied traffic that neither of the above-described methods appears to be quite satisfactory. In such cases, roads have been constructed as follows: The first course of stone is spread and thoroughly compacted, stone dust or sand being used to fill the voids and bind the stone to a certain extent. On this is spread a course, not less than 2 in. in thickness as measured after rolling, consisting of stone mixed with a natural asphalt binder of greater viscosity (or less penetration) than the asphalt used in constructing roads by the penetration method. There is reason to believe that natural asphalt products are superior to residuum products for this purpose.

To get satisfactory results in such construction, the stone is heated and is then machine-mixed with the hot asphalt, about 17 gal. of asphalt being used to the cubic yard of stone. This asphalt costs nearly double the cost of the ordinary residuum asphalt that is used for penetration work, and the cost of mixing being greater than the cost of construction by penetration brings the cost of this type of road considerably above the cost of the type of road previously described.

With an average haul of asphalt and stone of two miles, a certain road constructed two years ago by this method, with mixed surface 2 in. in thickness, cost 75c. per sq.yd., without any allowance being made for depreciation of machinery. A road surface of this type, including the bottom course, under average conditions with a haul for material not exceeding two miles, costs about $1.10 per sq.yd., and the cost of maintenance under heavy traffic should not exceed the cost previously given for the maintenance under medium traffic of a road constructed by the penetration method, that is, approximately 2c. per sq.yd. per annum.

Sand and Oil Roads—Another type of road which has been built by the Commission during the past six years in the Cape Cod district is the so called sand and oil road. This type of road is not recommended for construction where the traffic is constant and heavy, but rather where traffic is comparatively light and where crushed stone or gravel is difficult or expensive to obtain.

The first sand and oil road in Massachusetts was built by the Commission in 1905 and was constructed purely as an experiment. The method used on that road was as follows: All sods and loam were removed from the road. The road was then shaped for a width of 15 ft. to the cross-section to which it was desired to have the road completed. Asphalt oil was then distributed at the rate of about ¾ gal. per sq.yd., after which the road was harrowed and otherwise worked in order to thoroughly mix the sand and oil together. Another similar application of oil was then made and the harrowing and mixing continued, the surface being then covered with a thin layer of sand and thoroughly rolled, the depressions being filled by adding a little more oil and sand.

The following year the road was in such condition that it was absolutely necessary to treat it again, and another layer of oil was applied and covered with sand, rolled, and the depressions filled. This section of road received subsequently slight treatment to fill depressions, and is today in very good condition having had practically no treatment during the past two years. This crude method was not very successful on account of the fact that the surface was in very poor condition for about three years after construction.

One method under which several miles of this sand and oil road have been constructed is as follows: The roadbed is first graded to the profile and cross-section desired. Asphalt oil is then distributed on the road at the rate of ¾ gal. per sq.yd., and immediately covered uniformly with sand, and rolled with a light tandem roller. This process is repeated twice, using less oil in the two subsequent applications. After the third application of oil and sand, the road is watered and thoroughly compacted, using more sand where the oil shows on the surface.

The oil used for this method of construction should be of such consistency that it will require heating to about 200° F. before application. The sand used should preferably be such that not more than 10% will pass through a 30-mesh screen.

Even if the utmost care is used in the construction of a sand and oil road by this method, defects appear soon after the road is completed, but the expense of

repairing these defects is not great, and after all defects appearing after the first year's construction are repaired, very few defects subsequently appear. The top surface of this type of road has been built at costs varying according to conditions, from 20 to 35c. per sq.yd., not including the cost of grading.

A better though slightly more expensive form of constructing sand and oil roads is to mix heated sand with asphalt oil of a stiff grade, the mixing being done either by hand or machine, using about 16 gal. of oil to the cubic yard of sand, spreading the mixed material so that it will be 3 in. in thickness after rolling, the rolling to be done with a light tandem roller.

It has been found difficult to obtain a satisfactory smooth surface by this method without adding, after the road is completed, a light surface application of asphalt oil, followed immediately by a coat of sand and rolled with a light roller. Under this treatment, the slight depressions in the mixed surface retain a little more oil than the elevations, consequently take a little more sand, and a fairly smooth surface is secured. The cost of constructing this type of road varies from 35 to 50c. per sq.yd.

The writer desires to emphasize that these sand and oil roads are not recommended, except where the traffic is comparatively light and where crushed stone or gravel roads would be unusually expensive to build.

BUILT-UP GRAVEL ROADS—Still another form of construction that has been used during the past year or two is the so called built-up gravel road, this type being used where the traffic will permit, and where gravel prevails of a quality suitable for this type of construction, but not suitable for a gravel surface without the use of a foreign binder.

The method used is similar to that used for the built-up sand and oil roads. The lower layer of gravel is spread and thoroughly rolled, after which oil and gravel are applied. Three applications of asphalt oil and gravel are made, each layer of oil and gravel being sprinkled and rolled before the subsequent layer is spread. The use of ½ gal. of oil for each of three applications will give a good finished bituminous surface about 1½ in. in thickness. Such a surface must be kept covered with a suitable gravel until all signs of oil exuding to the surface shall have ceased, after which the casual observer could not distinguish any difference between this and a bituminous macadam road.

Many short experimental sections have been constructed, using different types, quantities and qualities of wearing material and binder. Some have been found to be entirely useless, others to be excellent, and still others indifferent. The types already described somewhat in detail as having been used have been adopted as a result of observation of these experimental sections.

MAINTENANCE UNDER PRESENT CONDITIONS—As previously intimated, the maintenance problem was very simple until the year 1906, at which time the effect of motor vehicles began to be quite evident. The Commission has experimented with practically every kind of material that has been advocated as a road preservative.

Changes from year to year in the kind and amount of traffic passing over the roads cause very frequent changes in the kind of material and methods to be used in maintenance of old surfaces. The method most generally used up to the present time has been to protect the surface with a bituminous carpet.

The kind of bitumen used on various roads differs with the kind of traffic over the roads. Where the prevailing traffic consists of motor vehicles, it has been found that on old macadam roads, a surface application of asphaltic oil, applied at a temperature of about 225° F. at the rate of ½ gal. per sq.yd., and immediately covered with fine gravel or screenings, having no particles greater than ½ in. in diameter and containing very little dust, makes a very satisfactory protective surface coating. If, however, the traffic consists of both motor vehicles and horse-drawn vehicles, with the latter in excess of the former, such coating is a very temporary protection. This is particularly emphasized when horse-drawn vehicles are heavily loaded on steel tires.

There are many miles of macadam road in the state treated as just described that will pass through their fourth season of wear this year. The original cost of this surface application is dependent upon the price of the bitumen, the cost of screenings and the length of haul of both materials. Two years ago the average cost was approximately 7c. per sq.yd., and as the cost of both labor and materials has been gradually increasing, the cost of such treatment is now greater, and will probably average approximately 9c. per s.yd. during the present year.

It is not to be understood that this treatment, even where the traffic is exclusively motor vehicles, will not require some annual repairs, but the cost of such repairs is very small compared with the first cost of this treatment; such repairs consisting only of covering small patches of road where the bituminous carpet has disappeared on account of poor original workmanship or some other cause. Judging from results obtained in the past, the total surface maintenance cost of many state roads should not exceed 10c. per sq.yd. for a period of four years.

As previously stated, a bituminous carpet with heavy asphaltic oil for a binder is not adapted to roads where horse-drawn vehicles predominate. One method which has been quite extensively used in many places for preserving the roads under this condition is to use a re[illegible] tar, the tar appearing to retain a s[illegible] surface under horse-drawn traffic [illegible] a greater extent than does the heavy [illegible]

It is perhaps impossible at the pr[illegible] time for any one to state just [illegible] weight, quantity and relative propor[illegible] of traffic of the two types will be c[illegible] successfully and economically by either kind of bitumen, but it is perfectly safe to say that if there are 200 horse-drawn vehicles and 200 motor vehicles per day passing over a 15-ft. road, neither of the described types is economical. In such a case the best method is to incorporate the bitumen to a depth of at least 1½ in. of the surface of the road.

SURFACE CROWN—In connection with bituminous surfaces, a condition that was not given proper consideration when such surfaces were first used is the proper crown of the road. Before bituminous surfaces were used, practically all macadam roads were built with a crown of ¼ in. to the foot, that appearing from experience to be necessary, but with a bituminous surface such a crown is not only unnecessary but may almost be considered dangerous for traffic. The crown quite generally adopted now for bituminous surfaces is from ¼ to ½ in. per foot. If the surface is properly built, such crown will permit the water to run to the sides and adds to the safety of travelers using either horses or motor vehicles.

MOTOR-TRUCK PROBLEM—The rapid increase in the number and capacity of motor trucks adds another problem to be solved in road building. Unless some limit is placed on the weight per square inch that must be sustained by road surfaces, it may become necessary to practically reconstruct many miles of highway that were built to sustain any traffic anticipated at the time they were constructed, but will not sustain the weight per square inch that now appears probable on account of the apparent competition among manufacturers to build trucks that will carry extremely heavy loads. The solution of this problem will require coöperation on the part of highway engineers and legislators.

Contractors for Municipal Work in Baltimore, Md., are at last successful in having eliminated the clause, which has been in all public works contracts since 1898, requiring bidders to name subcontractors. The city solicitor has advised the Board of Awards that the contention of the F. B. Bennett Building Co. that the clause was void because naming the subcontractors illegally restricted free competition in bidding was correct, and that it did not furnish sufficient grounds for rejecting the Bennett Co.'s bid. The clause was made a city ordinance in 1898 with the intention of restricting municipal work to local contractors, and is a survival of endeavors to restrict competition, which began in 1864 with an ordinance limiting awards to Union sympathizers.

A Device for Locating Underground Pipes

In many water-works systems there are mains and service pipes whose exact position is not known and not on record, and when repairs or new connections are to be made there is loss of time, money and work in trying to locate the pipe by trenching at different points. Electric devices have been invented to enable the exact location to be determind from the surface of the ground, and some of these have been found very successful in practical work. One of these is based on the principle of causing a slight flow of electric current in the pipe, which thus becomes a conductor; when an electric coil is brought within the electric field of this conductor, a current will be induced in the coil, and cause a sound in a telephone receiver connected to the coil. The sound increases or decreases as the coil is carried nearer to or farther from the underground conductor, but ceases when nearest to it (that is, directly over it). In using the instrument, wires from a small portable battery are attached to suitable connections, and the operator (with instrument in his hand and receiver at his ear) walks to and fro across the supposed line of the pipe, the exact line or position being indicated by the absence of sound, while his approach to or departure from this line is indicated by varying intensity of sound. To locate a service pipe, the battery wires would be connected to the house cock and hydrant, thus creating a current along the service pipe. This device is manufactured by the Modern Iron Works, of Quincy, Ill., and is used by a large number of water departments and water companies.

The city of Chicago has an ordinance which requires the metering of the water supply to certain classes of buildings, and in carrying out this work it is necessary to locate the position of the service pipe near the wall, as meters are placed as close to the building line as possible. The location of the pipe often involves excessive cost in excavating the basement floor to find the pipe, as the records are not complete or accurate. For work of this kind the water extension division has ten of these electric pipe locators. They are used also in locating mains where services are to be repaired or renewed, the records being in the same condition as those above mentioned, and especially inaccurate as to the distance to the mains. With the electric instrument, the main and the course of the service pipe can be located and traced readily, so that the repair gang knows exactly where to dig, and there is no loss of time and money in digging at various points to find a pipe whose location is indefinite. In one case the instrument was used to locate a service pipe crossing the property of a manufacturing plant and of which there was no record. To find it in the ordinary way might have involved a great amount of trenching over half an acre of land, but with the instrument described the pipe was very quickly located and traced. The use of the instrument is easily learned, and depends mainly upon the operator's ear getting accustomed to the variations in tone of the receiver. On the Chicago work it is handled usually by a laborer who has become proficient in its use.

As an illustration of the value of this device we have the following information from J. B. Prettyman, Secretary of the

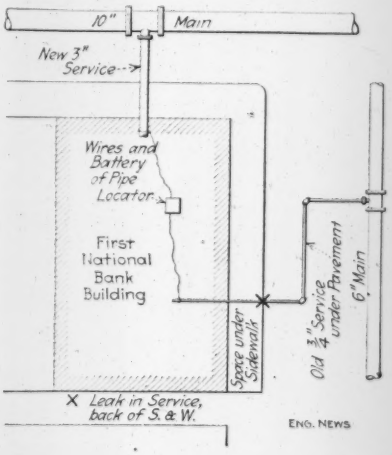

10" Main
New 3" Service
Wires and Battery of Pipe Locator
First National Bank Building
Space under Sidewalk
Old 3/4" Service under Pavement
6" Main
X Leak in Service, back of S. & W.
ENG. NEWS

DIAGRAM SHOWING LOST SERVICE PIPE LOCATED BY AN ELECTRICAL DEVICE; CHAMPAIGN, ILL.

Champaign & Urbana Water Co., Champaign, Ill. The First National Bank had a leak in the ¾-in. service to its building, and as the bank was erecting a new building and desired a larger service it was desirable to turn off the old service at the main. The slight amount of information available regarding the old service only served to perplex the water company, as it was to the effect that the service did not run straight out to the main. As the service was under the pavement, to locate it in the ordinary way would have been a difficult matter. The pipe-locating device was taken to the work, where one wire was connected to the old service and the other to the new service, which had been installed (although connection could have been made to a fire plug if the new service had not been available). Then the current was started flowing out through the old service, along the main and back through the new service to the pipe-locator battery. The arrangement is shown in the accompanying cut. The current-generating portion of the device consisted of three or four ordinary dry cells and a coil for boosting the current.

The operator then took the "locator," consisting of a coil wound around a core and connecting to a receiver similar to a telephone receiver. The coil was held so that it was level with the ground and when in the field of the lines of force sent out by the current through the pipe and not directly over the pipe a current was set up in the coil which caused a singing in the telephone receiver. This effect is caused by the lines of force cutting the coil diagonally. When directly over the pipe the lines of force cut the coil at right angles (the coil being level with the ground) and no current is started in the coil. It is a simple matter to follow the lost pipe when it is known that directly over the pipe no noise is heard and that to one side (even as small a distance as 3 or 4 in.) a noise is heard. Starting from the known location (the place where the connection was made), by finding the point of no noise and swinging the coil back and forth the periodical interruption of the noise caused by passing directly over the pipe enabled the pipe to be followed under the pavement and finally located where it tapped the main. The accuracy was proved by striking the tap in the center of the smallest hole that could be dug through the pavement to the main. For creating the necessary current this company utilizes the batteries of an automobile.

The Railways of India at the end of 1911 aggregated 32,839 miles, of which only 2452 miles had more than one track; this, with 6787 miles of sidings, brought the total trackage to 42,113 miles. The total mileage included 17,016 miles of 5 ft. 6 in. (standard) gage, 13,759 miles of meter gage, 1632 miles of 30-in. gage, and 432 miles of 24-in. gage. During the year 755 miles were opened for traffic and 841 miles were authorized, while at the end of the year 2674 miles were under construction. The number of passengers carried was 389,862,600, while the total freight carried was 71,268,000 tons, and the total train-mileage was 142,944,000. The average haul was 36.87 miles per passenger (from 8.78 miles for season tickets to 111.6 miles for first-class passengers), and 187.44 miles per ton of freight. Operating expenses represented 52.17% of gross earnings. There are 7415 locomotives (5713 with automatic brakes), 21,406 cars in passenger service (17,462), and 151,329 cars in freight service (only 56,721 equipped with automatic brakes.) The number of employees was 563,030; only 7699 were Europeans, 9877 Anglo-Indians, and the remainder natives. There are 5534 stations, 1926 of which have interlocking plants and 2124 have block signal instruments; during the year, 128 were equipped with interlocking plants and 309 with automatic instruments for signaling trains between stations. The total numbers of persons killed and injured were 2078 and 1869, respectively, but only 39 were killed in train accidents, and no less than 1126 of those killed were trespassers.

The government railways of India during the year 1911 earned a net profit for the Government of $16,000,000, after paying all operating expenses and interest charges on bonds issued by the Government. These railways now represent a total investment on which interest is being paid of $1,600,000,000, and the net earnings on the railways amounted to 4.49%.

Feathering Paddle Wheels for U. S. Self-Propelling Hydraulic Dredges

The two 24-in. hydraulic dredges "H. F. Taber" and "Robert McGregor," to be built for the U. S. Engineer Corps for use in river-improvement work on the Arkansas River, are to be equipped with feathering paddle wheels. In this type of wheel, the paddles or floats are not mounted radially, as in the ordinary type, but are attached to short lever arms pivoted to the frame of the wheel. Radius rods leading from these lever arms to an eccentric on the wheel shaft gradually change the angle of the floats during each revolution. Thus they are made to enter and leave the water more nearly edgewise and therefore with less loss from impact than would be the case with radial floats.

In this way a wheel of about 10 ft. in diameter can be made to act with approximately the same efficiency as a 20-ft. radial wheel. The advantage in having the smaller diameter of wheel lies first of all in the lesser weight of the wheel itself. Then, too, the wheel can be driven at approximately twice the speed, in revolutions per minute, of the equivalent radial wheel and for this reason a lighter and more efficient engine can be used. On account of the higher speed, the diameter of the shaft is correspondingly reduced and similarly all the other parts of the machinery are lightened. This is a point worth considering in a vessel designed for operation in shallow river channels.

It is true, however, that very few vessels on our Western rivers are equipped with feathering paddle wheels. This is chiefly due to the desire to keep the river boat free from all complicated mechanism. John M. Sweeney has commented on this subject, in an article on "The Most Economical Type of Boat for Operation on Western Rivers with an 8-ft. Channel Depth," published in ENGINEERING NEWS, May 5, 1910, p. 512, as follows:

> No one who has had experience with all the conditions to be met in river navigation—such as silt, ice, drift, shore landings and consequent wear and breakage—would attempt the use of feathering wheels without a full appreciation that it could be only a costly experiment, and that to give a service approaching regularity and avoid large expense bills, he would have to return to the radial paddle wheel.

These dredges, however, will be used only in low water, so that the difficulty with drift wood should be reduced to a minimum, and the problem of frequent shore landings, so important in the case of packet boats is, of course, eliminated. The principal dimensions of the boats are as follows: Length between perpendiculars, 192 ft.; beam, 44 ft. 4 in.; molded depth, 7 ft.; draft, loaded, 3 ft. 2 in.; displacement (long tons), 640.

Three boilers of the combination fire-tube water-tube return-flue type will be installed to work at 200 lb. pressure. The grate surface of each boiler will be about 45 sq.ft. and the heating surface 1685 sq.ft. The propelling engines are separate from those driving the centrifugal dredging pumps. They are of the simple, noncondensing type with 24-in. bore and 48-in. stroke, developing 800 to 900 hp. The cylinder heads are constructed with a raised seat and ground to fit the cylinder end so as to eliminate packing. The engines are designed to run up to 40 r.p.m., and the connecting rods are coupled direct to cranks on the wheel shaft, so that the wheel shaft is virtually the crankshaft of the engine.

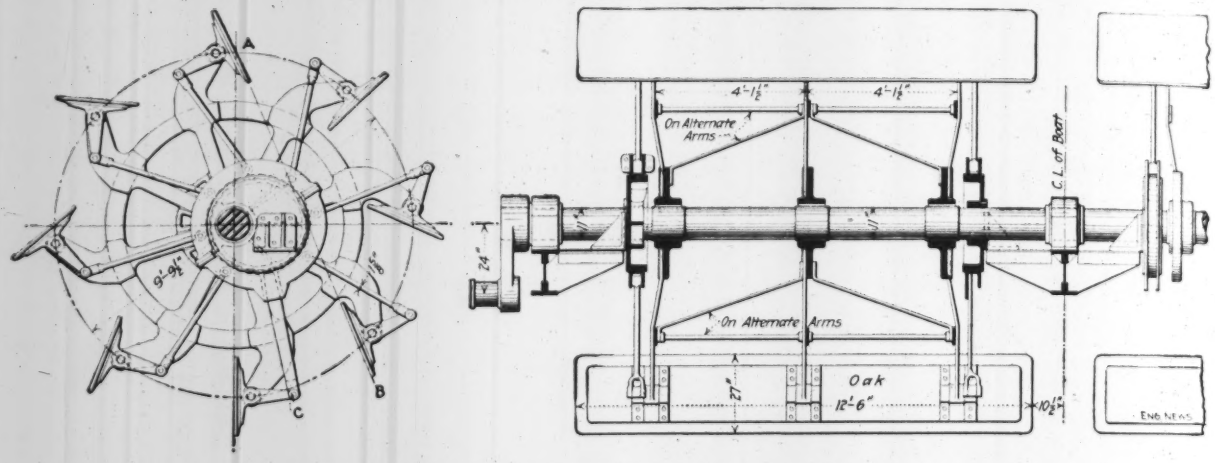


FIG. 1. ELEVATION AND END VIEW OF FEATHERING PADDLE WHEEL

PADDLE WHEEL CONSTRUCTION

Although there are two separate paddle wheels, they are arranged to both turn together on the same shaft. It might be supposed that two separate paddle wheels arranged to be turned in opposite directions if desired would be of great value in maneuvering the vessel. But experiments with wheels of this type on stern-wheel boats have not been altogether successful, and in the design of these dredges the regular practice on stern-wheel river steamers has been followed in providing what is virtually a single wheel and depending on balanced rudders between the wheel and the hull for the maneuvering of the boat.

As explained in Mr. Sweeney's article already referred to, a strong turning effect is secured by reversing the paddle wheel and driving water directly against the balanced rudders. Four of these rudders are provided. They are constructed of steel plating with reinforcing plates on the sides and are controlled by stocks of 10-in. extra-heavy wrought-iron pipe. The separation of the wheel into two units, as indicated in Fig. 1, permits the use of a center bearing on the wheel shaft.

A glance at the line *AB* in Fig. 1, drawn from the highest point of the pitch circle of the wheel through the face of the float which is about in the position for entering the water, shows that this wheel is equivalent in the efficiency of its floats to a radial wheel of approximately 20 ft. diameter. The angle of the float when leaving the water is even more favorable for this wheel than for a 20-ft. wheel of the radial type.

Each of the two wheel units is provided with eight floats, having each an area of about 28⅛ sq.ft. The float area

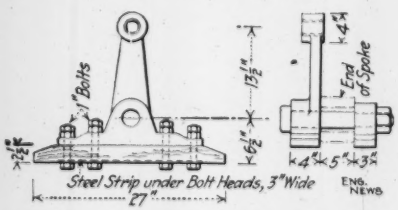


FIG. 2. SECTION OF FLOAT, SHOWING KNUCKLES AND FEATHERING LEVER

is directly proportional to the horsepower of the propelling engine and is inversely proportional to the diameter of the wheel.

The effective horsepower to drive the dredge 8.86 miles per hour, by comparison with a model approximately similar to the hull of the dredge, is about 450 hp.

Let

A = Area of two floats in line = 56.25 sq.ft.,

V = Velocity of wheel at center of floats in ft. per second,

v = Velocity of dredge in ft. per second = 13 ft.,

s = Wake; 20% of speed of ship = 2.6 ft. per second.

Then the propulsive horsepower, using the formula on p. 80 of Seaton's work on "Screw Propellers," is

$$\text{hp.} = \frac{120\,A\,(V+s)(V+s-v)\,v}{33{,}000}$$

Substituting 450 as the effective horsepower and solving for V, we obtain 18.5 as the velocity of the wheel in feet per second.

$$\frac{18.5 \times 60}{31} = 36 \text{ r.p.m.}$$

31 ft. being the circumference of wheel at float center; then total horsepower delivered to wheel =

$$\frac{120\,A\,(V+s)(V+s-v)(V+s)}{33{,}000} = 740 \text{ hp.}$$

assuming 0.85 for efficiency of propelling machinery = 740 ÷ 0.85 = 870 i.hp.

The above calculations give an estimated speed of 8.86 miles per hour with 36 r.p.m. of the wheel and a cutoff in the engines of 0.31%.

The apparent slip will be about 26%, but the real slip with 20% wake will be about 44%. The high slip will be necessary, in order to provide for towing about 500 ft. of floating pipe line at a reasonable speed.

With a cutoff of 50% of stroke the power developed can be run up to 1300 hp., and a speed obtained of approximately 9.55 miles, with about 40 r.p.m. The length of float is 12½ ft. and the breadth 27 in., giving a ratio of breadth to length of about 0.18. The thickness of the floats is made about 1/11 of the breadth, and they are bevelled at both edges to reduce the shock of entering and leaving the water. They are made of oak planks bolted to wrought-steel knuckles turning on pins or gudgeons at the end of the spokes of the wheel (see Fig. 2).

The frame of the wheel is built up with cast-steel hubs and wrought-steel spokes bolted into sockets in the hub casting, as shown in Fig. 3. The wheels have only one rim, placed about half way between the hub and the ends of the spokes. The spokes are enlarged beyond this rim in order to take up the bending moment due to the stress on the float and thus do away with the need for an outer rim. There are three sets of eight spokes each for each wheel unit, but only two eccentrics and sets of radius rods. The wheels are keyed to the shaft and the eccentrics are fixed to the framework supporting the wheel.

The eccentrics are placed one at each end of each wheel unit. They are made of cast iron of usual design. The eccentric is so mounted that its center comes on a horizontal line passing through the center of the shaft. The eccentricity (8 in.) is determined by the intersection of this horizontal line and the arc of a circle drawn with center at C in Fig. 1, and with a radius equal to that of the pitch circle for the gudgeons on which the floats are pivoted. The eccentric strap is made in halves bolted together and is of channel section. The radius rods are attached to it by means of pins passing through the flanges of the channel. The other ends of these rods are attached to the lever arms controlling the angle of the floats. One of the radius rods instead of being pivoted at the inner end is fixed in a socket on the eccentric strap, so that the strap is carried around by the rotation of the wheel.

Fig. 4 gives the general outlines the stern of the boat, showing the relation of the rudders to the wheels and the method of supporting the wheels on the overhanging beam at the rear of the main

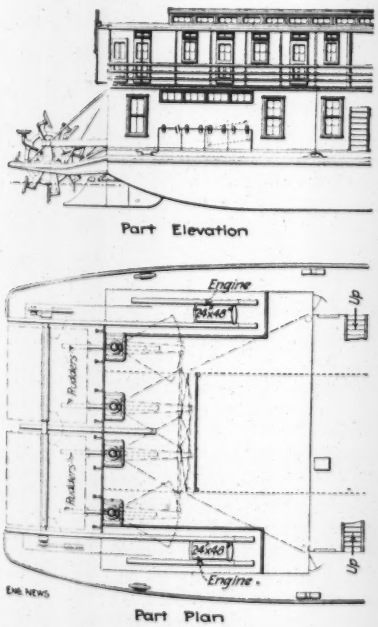


FIG. 4. GENERAL PLAN AND ELEVATION OF STERN OF DREDGE

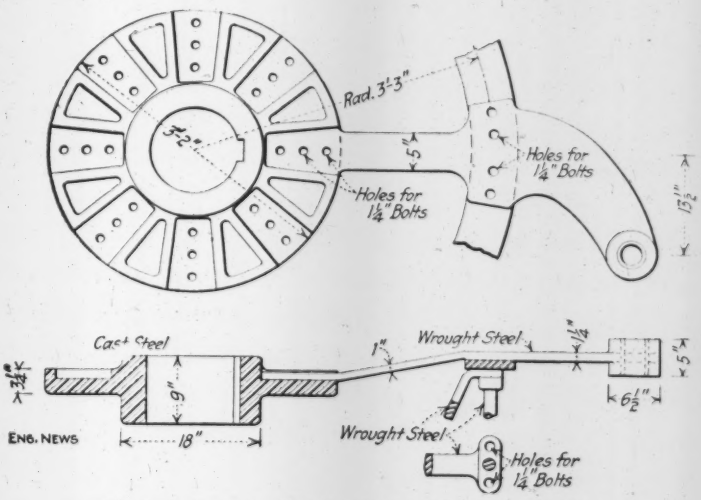


FIG. 3. DETAIL OF PADDLE-WHEEL HUB AND SPOKE

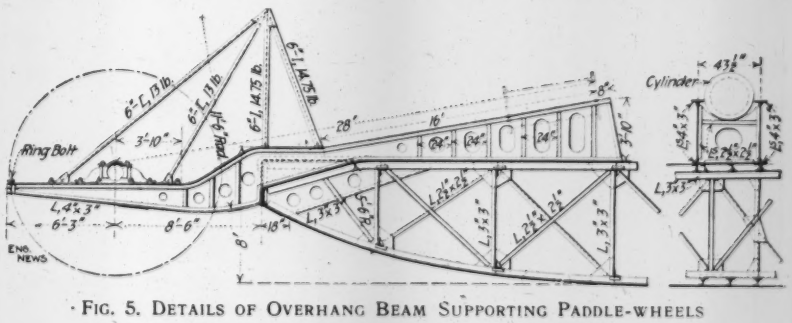


FIG. 5. DETAILS OF OVERHANG BEAM SUPPORTING PADDLE-WHEELS

framing of the boat. The details of this overhanging structure are shown in Fig. 5.

On account of the smaller size of the paddle wheels in comparison with those generally used on dredges of this character, it is necessary to have the paddle-wheel axles, and consequently their supports, nearer the water than in the regular type of vessel with a rear paddle wheel. This lower support is achieved by plate girders riveted to the main framing of the vessel, one between the two paddle wheels and one at the outside of each wheel. The reaction of the weight of the wheels is taken care of by the long inboard beam extending over the top of the main framing to the point where it supports the cylinders of the engines and furthermore by a vertical framework mounted on the end of the main framing, with two supports reaching out to the wheel-support beams.

The design of the wheel and framing were developed in the office of the Chief of Engineers, U. S. Army, Washington, D. C.

Waterproofing Engineering Works*

By W. H. Finley†

In very many engineering works it is necessary to ensure watertightness, but the paper given herewith relates more particularly to bridge floors of steel and concrete. This kind of waterproofing is of the utmost importance for bridges crossing streets, where even a slight leakage will produce unpleasant conditions which are likely to be the source of complaints against the company. And the reconstruction of the leaky floor will be a matter of difficulty, inconvenience and expense. It is well known that in many cases such bridges are defective from this point of view, and the paper and discussion show the difficulties of ensuring an absolutely waterproof or watertight condition. They show also some of the different methods used, and the results obtained.

*Abstract of a paper in the June number of the "Journal of the Western Society of Engineers," Chicago.

†Assistant Chief Engineer, Chicago & Northwestern Ry., Chicago.

The engineer must not lose sight of the fact that waterproofing, at best, is but an expedient, and will not take the place of proper designing, nor correct poor construction. If water is not got rid of in time it will seep through the ordinary materials of construction. The first requisite in the designing of any structure that must be water-tight is to provide means for getting rid of the water as directly and quickly as possible.

In the numerous track-elevation bridges around Chicago, whatever the type of construction, the usual practice has been to slope the floor from the center to each end, carrying the water back of the abutments, and there is where much trouble has developed. Although one may place broken-stone filling and tile drains back of the abutments, when the surface ice and snow melts in the springtime and the filling back of the abutments is still in a frozen condition, the water does not escape freely, but piles up and eventually seeps through at the end of the bridge and flows over the face of the abutment. In bridges having supports on curb lines and in the middle of the street, whether of flat-slab construction or metal troughs filled with concrete, cracks are likely to appear where joints are not provided over these supports, and where joints are provided trouble is likely to be experienced in preventing the seepage of water.

In waterproofing concrete, the integral method consists in adding a paste, powder, or lixiviating water to the concrete, mixing it with the cement, the mass of concrete as a whole or with the water. While doubtless any of these methods will make concrete impervious to water (as indeed can be done with ordinary concrete by careful proportioning and selection of aggregates, with subsequent care in placing), yet we know that monolithic concrete is apt to develop cracks from a variety of causes, and when that occurs there is likely to be a seepage of water through the mass. For that reason I have always preferred, for waterproofing engineering structures, what has come to be called the membrane method.

In asphalting a metal surface it is imperative that the metal be cleaned of all rust, loose scale and dirt; and oil must be burned off with benzine or by other suitable means. The metal surface must be warm to enable the asphalt to adhere to it, and the warming is best accomplished by covering it with heated sand, which should be swept back as the hot asphalt is applied. When waterproofing concrete structures it is very necessary that the surface be thoroughly brushed with wire brushes to remove all loose particles and get rid of any skin coat of cement. It should then be coated with a liquid asphalt primer, and better results will be obtained if, just ahead of the application of this primer coat, the surface is swabbed with gasoline.

I am not an advocate of felts or burlaps for ordinary waterproofing. An ordinary concrete surface, whether in a slab bridge or an arch, needs nothing but an application of a primer coat of asphalt and then a coat of liquid asphalt, after which a hot sand mastic, composed of one part asphalt to four of sand, can be applied with hot smoothing irons. On top of this it has been my practice to put on a swabbing coat of hot asphalt and then to cover the whole surface with washed gravel, particularly where rock ballast was to be used.

Over joints and ends of bridges it may be necessary to use burlaps for the added strength they give the asphalt in taking care of any slight movement. However, in cases of expansion joints, where any defined amount of movement is to take place, special means, such as copper flash joints, should be used. Burlap is a vegetable fiber and if used should be thoroughly saturated in a bath of hot asphalt of such temperature that it will not char or destroy the fiber. To apply asphalt to raw burlap in the field is wrong. If the asphalt is hot enough to penetrate the fiber, it is likely to be so hot that it will char or destroy it, and if the asphalt is not hot enough one gets only a surface coat.

There is a wide difference between the requirements for waterproofing to take care of ordinary rain water, or waterproofing where it is necessary to take care of the hydrostatic pressure of a head of water. In the latter case felt and burlap mat properly reinforced with concrete may be necessary.

A bridge over Turtle Creek, near Shopiere, Wis., on the Chicago & Northwestern Ry., consists of five 50-ft. arches and was built in 1869 of Joliet and local limestones. The seepage of water through the ring and parapet walls reached such a stage that it seriously threatened the life of the structure. In 1887 this arch was uncovered, and the top thoroughly waterproofed with California asphalt. In 1909, I took up some of this natural asphalt, and found it in first-class condition. The waterproofing of the arch at this time prevented any further leakage, and prolonged the life of the structure. I have waterproofed a number of old stone arches that were showing signs of disintegration due to the lack of drainage.

The three-track transverse trough-floor bridge over Main St. at Rockford, Ill., was built in 1893, and waterproofed with California natural asphalt. During 18 years there has been no complaint regarding leakage from the bridge, although it is over the principal street in Rockford. I attribute this largely to the fact that the water is drained from each floor

trough into drainage troughs and carried by pipes through the abutment. This avoids the trouble that is usually experienced at the end of the bridge where the drainage is carried from the center to each end. The only trouble with these

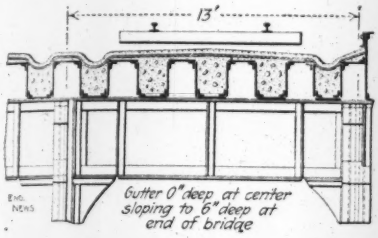


FIG. 1. WATERPROOFING AND SURFACE GUTTERS ON TRACK-ELEVATION BRIDGES; C. & N. W. RY.

troughs is from birds building their nests in them during extended dry spells.

In the subways on the Kinzie St. track-elevation work (shown in Fig. 1), the water is carried from the center of the subway to each end. A somewhat different method than I usually employ was used in waterproofing this bridge. The asphalt is imported mastic fluxed with Trinidad and Bermuda, and is covered by a layer of reinforced concrete. This work was done in 1905, and has proved very satisfactory, with the exception that there is some seepage of water at the ends of the bridge over the abutments.

Fig. 2 shows a proposed treatment of the ends of subways to prevent the possibility of water getting through and flowing down the face of the abutment. This is an attempt to seal completely, by the use of burlap mat instead of the usual bent-plate method that we have previously used.

DISCUSSION

L. J. HOTCHKISS—I have found the waterproofing proposition a difficult one in track elevation work. The author seems to regard a membrane as unnecessary and has had good success without it. Our work has been on flat-slab concrete construction where large areas have been covered with a comparatively thin sheet of mastic, with only a few inches of protecting ballast. Under these conditions we have not been able to secure a mastic which will not crack, and we regard a membrane of felt or burlap under the mastic as essential.

The author objects to the use of plain burlap as a membrane, and thinks it should be saturated before using. I have seen samples of saturated burlap, which, after lying around the office a few months, were so brittle they could be easily broken. The material is also rather stiff and correspondingly difficult to lay. We use plain 8-oz., open-mesh burlap laid five-ply.

Most of the work was done during the summer, but it was continued the first season until the weather had become quite cold. Leaks developed in this work later, and samples were cut out to determine the cause. It was found that the mastic was badly cracked, the lower layer of burlap not saturated with asphalt, and the second layer only partly saturated. The third layer, while well saturated, had not in itself been sufficient to prevent the water from coming through the cracks in the mastic. Then we cut out samples of the work done in warm weather. No leaks had developed, and every layer of burlap was completely saturated and in first-class condition. From this experience I am convinced that work of this character should be done in warm weather or where the structure can be kept warm by artificial means.

The author advocated the adhesion of the waterproofing material to the surface to be waterproofed. We have disregarded it entirely, and have endeavored to make the waterproofing tight around the edges of the structure. At the right-of-way lines it has been carried up on to the parapet walls, turned into grooves and protected with a covering of concrete. It has been carried down over the back of the abutment and covered in a similar manner.

This method is fully equal to the other in results and it is much easier. In many instances it is impossible to secure adhesion under working conditions. No asphaltic preparation of which I have knowledge will stick to wet concrete. Under track-elevation conditions, as well as many others, a given track can be put out of service for only a limited time and the work must be done with expedition. If it rains the night before waterproofing is to be done, you cannot wait for the deck of your bridge to get dry, and if waterproofed while damp, adhesion cannot be expected.

MR. FINLEY—My objection to the idea of waterproofing sealed only around the edges, is that if there is the slightest puncture, it admits water under the whole surface, and water that is covered up and not permitted to evaporate is bound to penetrate the concrete. It is quite possible to make asphalt adhere to concrete, and in so doing we remove the possibility of any opening that will admit moisture or water to the whole surface.

My first attempt with asphalt was on arches where the whole surface was exposed, and my endeavors were to make a covering that would adhere to and prevent the infiltration of water. In my first attempts to waterproof a concrete surface, I tried heating the surface, but found that this drew up the moisture. After applying asphalt in a number of such cases I found I could roll it up like a blanket. It was at that time that I conceived the idea of applying asphalt as a cold mixture, mixing it with gasoline to hold it in solution and permit it to be applied as a cold mixture. At that time no one in the United States was supplying any such product.

W. F. STEFFENS—On the Boston & Albany R.R. we think favorably of a structure having I-beams embedded entirely in a solid slab of concrete. In erecting smaller types of such slabs we have found it desirable to divide the work into separate sections for each track. The slabs were water-tight, but in the joint between the original slabs and the concrete placed at a later date, a small leak developed. The waterproofing is a heavy coating of coal-tar pitch. We have been able to eliminate the leaks by providing a channel in the joint, into which soft pitch or asphalt could be subsequently poured, finally applying the finishing coat over the entire surface.

For larger structures we have built the slab as a unit for the entire number of tracks, afterward rolling it into place. The waterproofing for these is a membrane consisting of alternate layers of felt and asphalt, with a protection course of brick laid in hot asphalt. In moving this large mass, unless the track supporting the rollers is absolutely rigid, there is a tendency for the slab to be separated and to tear the waterproofing membrane. Experience has shown that it will be desirable in this character of work to design the structure with a convenient number of joints filled with a soft asphalt and capped by a membrane of something more elastic than the usual felts.

In waterproofing the smaller slabs, we have found it impossible to secure a bond between the concrete and the pitch in cold weather or if the surface is damp. It is necessary that the temperature of the surface to be coated be sufficiently high to afford a bond. In some cases it

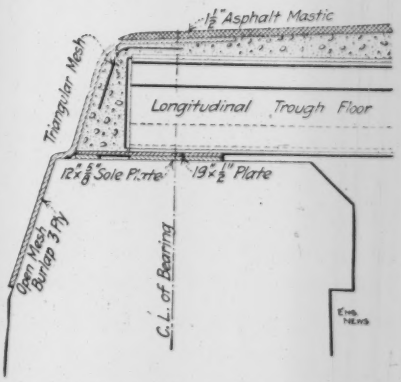


FIG. 2. PROPOSED METHOD OF WATERPROOFING AT THE ENDS OF TRACK-ELEVATION BRIDGES

has been possible to heat the surface by pouring on gasoline and igniting it. In other cases it has been necessary to delay the work until proper conditions of weather and temperature could be secured.

In a large bridge at Worcester, Mass., it has been found necessary to provide expansion joints liberally at critical points. The question of waterproofing these properly has been quite a problem. We are elevating the surface of the slab at these points as far as possible to prevent water reaching them. The waterproofing membrane will be depressed as it passes the expansion joint, and the pockets thus formed will be filled with a soft asphalt. The waterproofing membrane will be reinforced by using thin sheet lead between the courses of felt or fabric.

F. E. DAVIDSON—I should like to know how to waterproof a rubble-stone masonry wall, under a hydrostatic head of about 5 ft.; for instance, the basement wall of a heavy building, where it is impossible to get at the outside.

J. W. PEARL—If you will start a man to work on that wall with plain portland-cement wash, at a temperature that will dry the coating, and keep the man at work on the wall, it will be waterproofed perfectly. I have accomplished that in a water-works intake well built of porous brick.

W. L. ARMSTRONG—Waterproofing is not so much in the material used as in the execution of the work. The engineer is frequently handicapped by the conditions under which he has to work. In waterproofing a structure of a large number of tracks, very often he can only get the use of one track at a time. He has to work on this strip between tracks, sealing the waterproofing to that laid first. In the meantime, the men are walking over it; it gets covered with a film of dust and dirt, which, if not carefully cleaned off before the next layer of waterproofing is put on, forms a seam where moisture will get through.

Concrete can be made practically waterproof without the addition of any material; but the problem is the waterproofing of the cracks which are bound to occur in every concrete structure. This is particularly true in some types of bridges. Take the case of bridges of two or more spans, supported by bents or piers. There will be deflection in the spans, which will inevitably result in a crack in the concrete over the support. Then the question becomes one of applying a material that will remain intact over that crack. The use of a mat of some kind in the waterproofing may not be necessary over the span, but it is absolutely necessary that something of that kind be employed over the support where the crack is apt to occur.

In sealing the waterproofing to the concrete, especially over supports, wherever the crack occurs, there will be a movement first apart and then closing up as the load goes over the structure. There will also be a tendency for the crack to widen in cold weather, and if the waterproofing is sealed absolutely to the structure, the stretch must occur in the width of this crack. If it is not absolutely sealed, the stretch may be distributed over a greater length.

NORMAN MALCOLM—In some subway work on the C., B. & Q. R.R. and other railways, in order to provide satisfactory waterproofing over the joint between street and sidewalk-slab spans, it has been necessary to lay the membrane at such places over a piece of 1-in. or 1¼-in. pipe, withdrawing the pipe as the work progressed. This leaves a loop which can then be crushed down flat on the surface so as to form no obstruction to the escape of the water, and be thoroughly cemented or saturated with a waterproofing material. When displacement takes place at the joint, this can stretch out. On railway bridges it is expensive to have to tear up tracks and replace ineffective waterproofing. In many cases the cost of doing this would be many times the cost of doing the work in the best way with the best material during the original installation.

CLIFFORD RICHARDSON — The paper states that "the first requisite in the design of any structure that must be watertight is to provide means for getting rid of the water as directly and quickly as possible." There is nothing truer than this and it is something that is too often neglected, whether the structure is to be waterproofed or not. Only recently, where no provision was made for the removal of water collecting behind the concrete lining of a railway tunnel (which was not waterproofed), the water has forced itself through the more or less porous concrete, has saturated it, and freezing in winter has disintegrated it to an alarming extent.

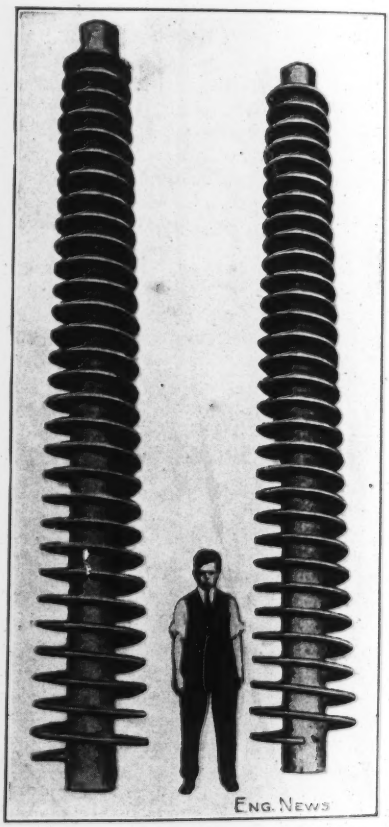
From years of experience it appears that the only way to prevent this is the immediate removal of the water before sufficient pressure can arise to force it into or through the structure. Such a provision at points over supports where cracks generally are found will be an assistance in the prevention of leaks. This can be accomplished by flashing, or a weeper, to the exterior of the structure, providing immediate relief. The strain on the waterproofing will thus be reduced.

If a membrane is used as an auxiliary it should be a saturated fabric and not a felt, for several reasons. A fabric can be fitted closer to the surface, owing to its greater pliability and because it is less liable to tear. It is very necessary, however, that the fabric should be carefully prepared. Many of those on the market are quite unsuitable for the purpose, owing to unsatisfactory methods of manufacture.

The author brings out a very important point in his paper—the necessity of carefully cleansing the surface of concrete or metal before the application of waterproofing and of having it dry and warm, when possible. With cold surfaces the application of a coat of gasoline, before the use of the bituminous paint, may be a desirable precaution with such material of a certain character, but is not always necessary. In no case can the paint course be omitted with safety.

A Difficult Steel Casting

The accompanying cut shows a difficult piece of steel foundry work recently turned out by the Penn Steel Casting & Machine Co., of Chester, Penn. The casting is a screw used in a machine for pressing oil from fish. Each screw is 19 ft. 4 in. long, and the thread upon it is 29½ in. wide at the large end and 20 in. at the small end. The sharp on which the thread is formed has a 6-in. core running through its entire length. The



7590-LB. STEEL CASTINGS
(Penn Steel Casting & Machine Co.)

total weight of the casting is 7590 lb. Walter F. Bickley, the President and General Manager of the company, states that 17 of these large screws have now been successfully cast. The steel used for the casting is melted in a 30-ton acid openhearth furnace and the mold is fed through a single gate.

A New Electric Miners' Lamp: History of Mine Lighting*

By D. B. Rushmore†

Torches were used by the early Romans for mine lighting, and these were followed by open lamps or earthen jars filled with tallow or oil, and later by candles. In early coal mining, explosive gases seldom occurred, and if they were encountered, the danger of explosion was materially diminished by the absence of any ventilating system and the consequent insufficient circulation of air to form with the methane an explosive mixture.

As the art advanced, the danger of firedamp became more apparent, and methods for testing the air were resorted to as early as in the fifteenth century. The method of testing consisted in lowering a dog in a basket down the shaft. As soon as he encountered firedamp he would commence to howl, after which he was withdrawn and a leafy bush was fastened to the end of a rope and run rapidly up and down the shaft. This so disturbed the accumulation of gas as to cause it to rise out of the shaft.

Later this odd method of testing was improved upon through the discovery that a light inserted in a body of firedamp would produce a blue flame. Candles were used for this purpose, and when firedamp was thus discovered, brushing or some other primitive method of fanning was resorted to for driving out the gas.

In some instances the gas was burned away, regardless of the danger thereby incurred. A man, wearing a well moistened coat and a mask with glass spectacles, descended in the mine a few hours before each shift. With a long stick, to which was fastened a burning torch or candle, he would crawl on the floor with the stick so raised that the light would sweep the roof and ignite the gas which it encountered. In this position the flame of the explosion would pass over him, after which he would retreat from the gases resulting from the combustion. The occurrence of serious accidents resulted in the substitution of a method by which the candle was moved along the headings by means of an endless rope, which was supported on pulleys near the roof and could be operated from a safe point.

In metal mines, and even in coal mines where the gases contained in the atmosphere are sufficiently diluted to render them harmless, illumination may be had by any form of naked light. The most common of all miners' lamps is the small tin lamp, which generally is carried on the miner's cap. A cotton wick extends through the spout into the fluid, which is generally some kind of petroleum product. While this lamp, when trimmed and kept in order, gives a fairly good light, the objections to its use are many. The almost continuous smoking seriously impairs the purity of the air and thus handicaps the miner in his work. It is easily blown out by blasts and drafts. The leakage of oil from the lamp is a constant annoyance, and the time required for refilling and trimming the lamp is considerable.

The acetylene lamp, used to a considerable extent in a number of mines, is a marked improvement on the oil lamp. Not only is the illumination materially better, but the smoking and leakage of the oil lamp are practically eliminated. The difficulties of handling seem, however, to have prevented its more general adoption.

In collieries where considerable quantities of firedamp and coal dust are liable to collect, the lamp flame must be protected from direct contact with the gas and it becomes necessary to use some sort of safety lamp, either exclusively or for purposes of inspection, preliminary to the removal of the gas.

In 1815, Davy invented the safety lamp which bears his name and the principle of which is embodied in the numerous safety lamps of later inventors. Although many improvements have been made in the safety lamp, it is still far from perfect; and the present indication is, that, in order to obtain a perfectly safe and reliable lamp, the electric light must be resorted to. Several types of safety lamps of more or less ingenious design have been placed on the market and are in actual use in the various gaseous coal mines.

The Davy is an ordinary oil lamp, the flame of which is surrounded by a cylinder of wire gauze, with a top of the same material. The principle of this lamp is that the cooling effect of the wire gauze prevents the propagation of the flame from the inside of the lamp to the outside atmosphere. After the lamp has been filled with oil and lighted, it is locked so as to prevent the miner from having access to the flame, the wick of which is trimmed by a wire passing up through a close-fitting tube from the bottom.

The Clanny lamp is similar to the Davy, with the exception that the lower portion of the wire-gauze cylinder is replaced by a short glass cylinder, giving a somewhat better illumination.

Stephenson's lamp has a long cylinder of glass surrounded by wire gauze, and bonnetted above by perforated copper. The air feed is also through the gauze, going underneath and into the cylinder to the flame, thence out of the top as usual. This keeps both cylinder and gauze cool, and its relative security rests essentially on the regularity of the draft, for if the inside air becomes overheated the light goes out; so it must be suspended properly.

The Marsaut lamp is an improvement upon the Stephenson type, and can safely stand a fair amount of tilting. A great difficulty is experienced, however, in relighting it, and because of the winding path pursued by the feed air, proper

Figs. 1 and 2. Electric Miners' Lamp with Tungsten Filament and Portable Storage Battery

Fig. 1. As a Head Light Fig. 2. As a Hand Lantern

*Reprint of an article in the July, 1912, "Bulletin" No. 67, of the American Institute of Mining Engineers.

†Engineer, Power and Mining Dept., General Electric Co., Schenectady, N. Y.

circulation does not take place until the lamp gets hot.

The Hepplewite-Gray lamp admits the air at the top, down four tubes and through an annular chamber above the oil vessel. The only gauze employed is that covering the outlet and the annular inner chamber. A serious difficulty with this lamp is its liability to be extinguished when suddenly lowered.

In the Dick port-hole lamp, the air enters the lamp above the case, passes through the gauze, then descends to the flame, while the products of combustion rise inside the lamp to be emitted through circular holes at the top of the bonnet. The bonnet is made of a seamless steel tube and is light and strong.

The Wolf benzine safety lamp[1] is a departure from the above safety lamp in that (1) it burns benzine or naphtha, (2) it contains a self-igniter which permits the relighting of the lamp 50 times without opening, and (3) it contains a locking device which cannot be opened except by the use of an exceedingly powerful magnet.

While the safety lamp possesses great value as a gas detector, it is open to several serious objections. The first is the possibility that the gas, entering the lamp and burning inside the cylinder, may overheat the gauze which will then permit the flame to pass through it. Several types of lamps, however, are arranged to be self-extinguishing in case of ignition of gas inside the gauze. This is, of course, objectionable, as it will leave the men in darkness when such a danger occurs. The temptation of the miners to relight extinguished lamps, or open them for lighting pipes, etc., is very great and has in many instances resulted in serious explosions. Finally, the illuminating power of the lamps is very low.

For the above reasons, safety lamps of the ordinary type are being replaced in many localities, especially in bituminous coal mines, by portable incandescent lamps. This type offers numerous advantages: increased safety in explosive atmospheres, increased illumination, ability to concentrate the light on a certain area, reliability and simplicity, elimination of smoke, cleanliness, smaller fire risk, etc.

The Electric Mine Lamp

An objection often raised against the electric lamp is that it offers no means of indicating the presence of firedamp. Several devices have been proposed, such as providing spiral wires coated with salts of platinum, etc.; but there seems to be at present no really satisfactory solution of this difficulty, although there is no reason why a solution should not be expected. To attempt to find a satisfactory firedamp indicator is, however, merely to delay the general introduction of electric lamps; and there seems to be no real necessity for such an addition to a miner's lamp. The firedamp detector might well be an entirely separate instrument, which could be installed in places where the firedamp is expected to form first, such as near the roof, or in cavities therein. There is no reason why one or more gauze lamps should not be supplied with each batch of electric lamps and hung in the working place where they can be easily seen, and where any outburst of gas would be most likely to occur.

Numerous electric mining lamps have been designed but few have proved efficient and durable. The design in the United States and abroad has followed very different lines. In Europe the hand lantern has been almost exclusively considered, while the tendency here has been toward the perfecting of a combined hand lantern and head light. This is the logical result of the fact that the most satisfactory working results can be obtained by a head light, whose reflector concentrates and throws the light in the direction in which the miner works.

A new electric miners' lamp of improved design has recently been developed by the General Electric Co. to meet the increasing demand for a safe and reliable lamp. The idea of a systematic investigation as to the possibilities of developing such a lamp originated with W. J. Richards, vice-president and general manager of the Philadelphia & Reading Coal & Iron Co., to whom credit is due for his very active assistance.

The lamp is of the combination hand-lantern and headlight type, and consists of a miniature tungsten lamp-unit, operated from a light storage battery. The lamp is provided with an efficient reflector, designed to illuminate a 9-ft. circle at a distance of 4 ft. from the lamp, and photometric records show about 2.5 or 3 cp. at a distance of 2 ft. The battery has a capacity of 5 amp.-hr., and is of sufficient size to operate a lamp from 12 to 14 hr.

When used as a headlight, the lamp, with its reflector, is fastened to the miner's cap and connected by means of a flexible cord to the battery, which is carried on a belt or from shoulder straps, as shown in Fig. 1. When used as a hand-lantern (Fig. 2) the lamp socket is removed from the cap receptacle and inserted into the receptacle on the side of the battery, simply taking the place of the cable attaching plug.

Some of the important points in connection with this design are substantial construction, light weight and compactness; complete inclosure of all conducting parts, use of an absorbent for the electrolyte to prevent spilling, small number of movable contacts, increased efficiency of a 4-volt lamp, efficiency of the reflector, impossibility of charging with reversed polarity, instant convertibility from hat-lamp to hand-lantern. These features will be considered in the order in which they have been mentioned.

Special care has been taken to select all materials used in the construction to withstand the hard service to which this lamp may be subjected. The steel battery case is drawn from a single plate and is therefore seamless. The battery jar is not of the brittle rubber commonly used, but has some elasticity left in it, so that should the steel case receive a blow, there is little chance of the battery jar being cracked. The cord from the battery to the lamp is metal-armored where the greatest wear and strain occur but perfectly flexible where flexibility is required. The battery case is locked with a magnetic lock which also locks the attaching plug in the receptacle and prevents this plug from working loose and permitting the formation of a spark. The hat-lamp is sealed with a lead seal which must be broken before the miniature lamp globe can be removed.

This outfit has been designed, as already explained, for use as a head- as well as a hand-light, and therefore the weight of the battery, which must be carried on a belt, in the pocket, or by shoulder straps, has been kept at the minimum consistent with strength and durability. The battery is flat and compact in order that it may lie as close as possible to the body. It weighs approximately 3 lb. and measures 6½ by 4⅝ by 1⅛ in.

In order to prevent accidental short-circuits, causing sparks, all live parts are totally inclosed in molded compound. The battery terminals, attaching plug, hat receptacle and lamp holder are all molded from hard fire- and acid-proof compound and thus perfectly protected from corrosion due to acid spray or gases.

An absorbent is used for separating the battery plates and also fills up the extra space in the battery, except the mud space. This absorbent acts like a sponge and holds the electrolyte in the battery even though it be inverted for some time.

Where low voltages are used, the pressure drop caused by the contact resistance may be serious. The movable contacts in this lamp have, therefore, been reduced to a minimum and have been so designed that they come together with considerable pressure.

The increased efficiency and life of the apparatus is principally due to the improved tungsten lamp. A 2-volt lamp is somewhat inefficient and has a comparatively short life. This is due to the cooling effect of the large leading-in wires on the short filament. This cooling by conduction reduces the temperature of about one-third to one-half of the filament to a point where little or no light is produced. In order to produce the rated candle power, the rest of the filament must be operating at a temperature far

[1] "Transactions," Am. Inst. Min. E., Vol. xiii, 129 to 132 (1884-85); xiv, 410 to 418 (1885-86).

above a safe value, with a consequent unreliability and shortening of life.

The filament of the 4-volt lamp, for which this outfit is designed, is about twice as long as a 2-volt filament, so that the percentage of length cooled by the leading-in wires in a 4-volt lamp is about one-half that in a 2-volt lamp. This allows the rest of the filament to be operated at a safe temperature, giving a reliable lamp of long life. The filament is, however, not so long as to cause mechanical weakness.

The reflector is made of stamped steel, enameled both inside and outside, thus absolutely protecting it from corrosion. Tests have shown that white porcelain enamel forms one of the best possible reflectors, and is very durable and easy to keep clean. The lamp globe is protected from injury by a glass plate fastened to the rim of the reflector by a spring. This glass further tends to prevent dust from accumulating on the inside of the reflector.

The contacts on the battery terminal and plug are made concentric, so that no matter how the plug is put in the polarity must be the same each time. A separate plug is supplied for use in charging, and can be wired permanently on the charging rock with its polarity correct. It will then be impossible to charge the battery from this plug with reversed polarity.

While the demand for an electric mine lamp seems to be almost entirely for one to be worn on the cap to supersede the present oil lamp, it appears very desirable to have an outfit that can quickly and readily be converted into a hand-lantern. This has been accomplished by designing the lamp so that, by a quarter-turn, it can be removed from the hat receptacle and inserted, by a quarter-turn, into the plug-receptacle on the side of the battery.

Signal Bridges of Special Design

Signal bridges of light and economical construction have been used in some cases on the French State Railways, where numerous tracks require long spans but where reconstruction work may necessitate changes in the signals and bridges. The cantilever bridge in Fig. 1 is 87 ft. span between the columns or towers; the cantilever arms are 31.27 ft. long, carrying a suspended span of 24.5 ft. and having short anchor arms on which are counterweights of old rails.

In July, 1911, two additional tracks were completed at the Batignolles tunnel, near Paris, making eight tracks in all. This necessitated a rearrangement of the signals at each end of the tunnel, and it was found difficult to place them effectively; 18 signals are required at the Paris end and 10 at the Batignolles end. The plan adopted was to put two long-span signal bridges near the ends of the tunnel, one carrying signals for one direction and the other carrying those for the opposite direction. The arrangement of the tracks governed the location of the supporting towers, but it was necessary to extend the bridge beyond the towers to carry the signals over the outer tracks. Further, the extremely heavy traffic rendered it impossible to abandon any tracks during the erection of the bridges. The system adopted, with a suspension deck, is shown in Fig. 2.

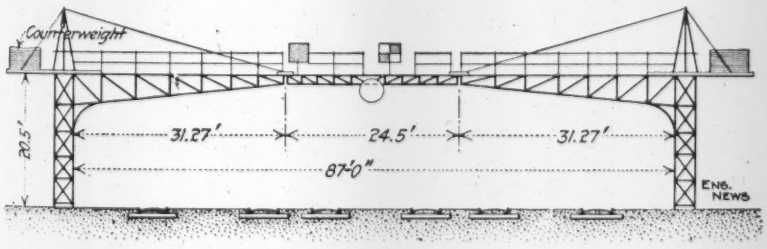


FIG. 1. CANTILEVER SIGNAL BRIDGE; FRENCH STATE RAILWAYS

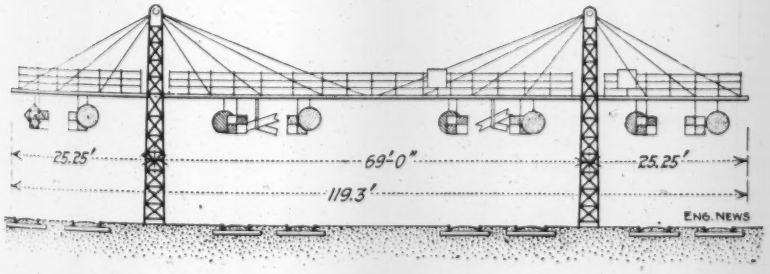


FIG. 2. SUSPENSION SIGNAL BRIDGE SPANNING EIGHT TRACKS AND CARRYING 18 SIGNALS; FRENCH STATE RAILWAYS

Each bridge has two towers 69 ft. between centers, from the tops of which is suspended the deck; this is nearly 120 ft. long, the ends projecting 25 ft. beyond the towers. The deck is 21.15 ft. above the track and the signals are hung beneath it at the standard height of 15.7 ft.; this arrangement makes the signals more conspicuous than if they were mounted above the bridge. The legs of the towers are steel angles, and the bracing is of plain bars. At the top of each tower is a 4-in. shaft. To these shafts are attached 14 pair of cables, all 0.6 in. diameter. The cables are connected to the deck at points about 8 ft. apart, being attached to stirrups fitted to pins in the webs of the steel channels forming the longitudinals. On the outer ends of the deck are reinforced-concrete slabs forming counterweights, so as to insure that the towers carry only vertical loads. The two longitudinals are composed each of two channels, suitably cross-connected and carrying a deck (about 3 ft. wide) of checkered plates. The use of two channels insured lighter weight of the individual parts and gave a better attachment for the cables than a single channel of larger size. A stairway is built to each tower, and a hand-rail is formed of uprights and galvanized bars.

ERECTION

In spite of the long span, the weight and subdivision of members enabled the erection to be done easily, without falsework and without interfering with train movements. The only difficult matter was the erection of the towers. These were built near the site and placed by means of a traveling crane, which set them on end upon the footings already provided. This was the only part of the work that had to be done at night. The channels for the deck (in lengths of 28 ft.) were then raised and riveted to horizontal angle struts at the proper height, the channels projecting an equal distance on each side of the tower; then the first cables were attached to their ends, after which the cross braces were fitted. This gave a platform sufficiently stable for the workmen engaged in extending the deck. These extensions were built in lengths of not over 8.2 ft., the outer end of each being attached to a cable from the tower. The work was advanced equally on both sides of the tower to insure stability.

At the center of the bridge at the Paris end of the tunnel is a small wooden cabin for a man who telephones the train movements to the signalman, who has a very restricted view from his tower.

The above description is taken from an article written by Mr. Froebe, Division Engineer of the State Railways, and published in the *Revue Generale des Chemins de Fer.*

A Plant for Testing Fire-Proof Tiling

Some interesting tests of the strength of wall panels of hollow-tile construction were recorded in our issue of June 20, p. 1181. From information obtained through the National Fireproofing Co., we are able to give herewith some description of the plant used in making these tests and some supplementary information as to tests of wall panels and floor slabs of tile construction.

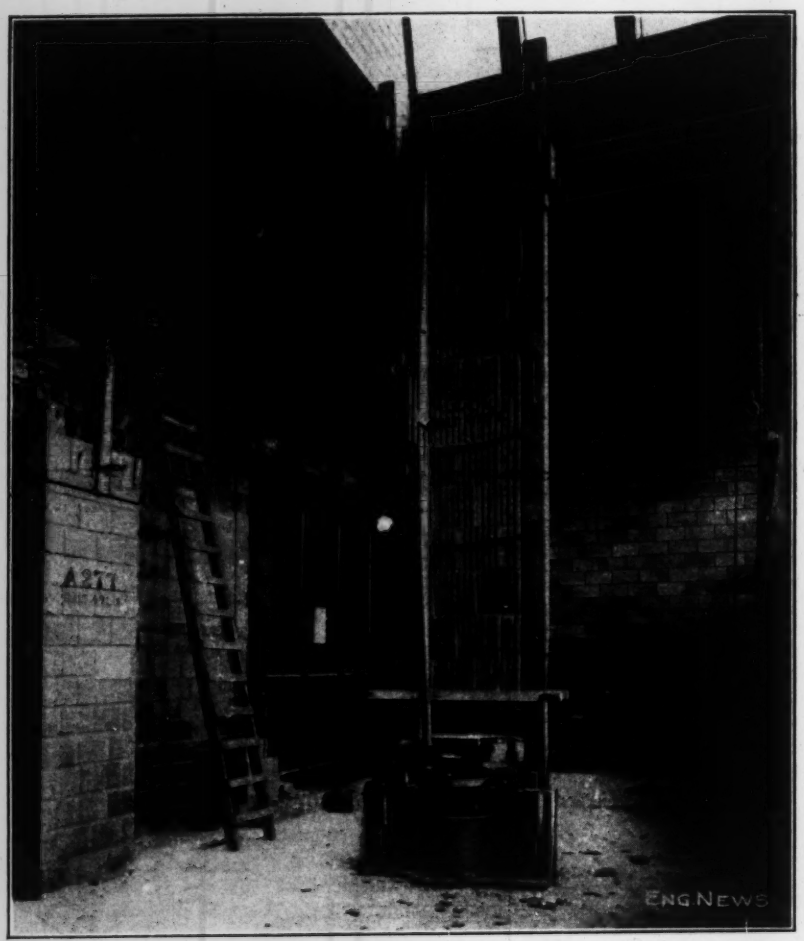


FIG. 1. TESTING MACHINE (WITH TILE WALL-SLAB IN PLACE) AT THE CHICAGO PLANT OF THE NATIONAL FIREPROOFING CO.

TESTING PLANT

This is an important feature of the company's Chicago plant, and is utilized for testing the strength of the different styles of hollow-tile blocks, as well as of columns, walls, etc., built up of these blocks. In order to give weight to these tests and to eliminate any element of partiality, the tests are conducted as a rule by representatives of a testing company. The testing room is about 20x48 ft. in plan, with an adjacent room equipped with a machine mixer for preparing mortar and concrete. The principal equipment of the testing room is a vertical hydraulic testing machine of 300 tons capacity, with guides high enough and far enough apart to admit of testing specimens up to 12 ft. in height and 3 ft. in width. The cylinder and ram are set on a concrete foundation, and the ram has a spherical bearing for the lower (sliding) crosshead, so as to insure uniform pressure. The upper crosshead can be fixed at any desired height in the guides, being secured by keys fitted to openings in the latter. For handling the specimens and the upper crosshead, there is a traveling crane which serves the entire floor and has a clear headway of 20 ft. This crane is operated by hand by means of an endless chain hanging within reach of the floor, and its trolley is moved in the same way. The trolley carries a 3-ton chain hoist. At one side of the room is the pressure pump.

In the tests of wall panels already mentioned, the panels were set plumb and carefully bedded in plaster of paris at top and bottom, this being allowed to set under light pressure before the test loads were applied. These loads were applied generally in increments of 10 tons every two minutes. A deflectometer was applied to the panel to show the lateral deflection (or buckling) from the vertical; the longitudinal deformation (or compression) was determined by an extensometer attached directly to the top and bottom of the specimen. Both of these instruments were graduated to 0.01 in. To prevent injury to observers from flying particles when the large test specimens fail (as in the case of panels and columns) panels of wire netting in wooden frames are hung against the guides, while a rope coiled loosely around the guides and specimen prevents the wreckage from falling to any great distance over the floor.

Fig. 1 shows the testing machine and the crane. In the machine is a wall panel tested to failure (see first column of Table I), and at the left is another panel which has been tested in the same way (see second column of Table). The extensometer is in place; also the rope loops to prevent fall of wreckage, but the wire-netting screen has been removed.

TABLE I. RESULTS OF TESTS OF WALL PANELS OF HOLLOW TILE CONSTRUCTION

Type of tile block	Natco	Monarch
Size of panel	12x3 ft.	12x3 ft.
Size of blocks	8x12x12 in.	8x12x8 in.
Area in compression	101 sq. in.	144 sq. in.
First sounds, total load, lb.	166,000	406,000
Actual load per sq. in. of area in compression lb.	1644	2820
Failure, total load lb.	356,000	506,000
Actual load per sq. in. of area in compression lb.	3525	3514
Horizontal deflec. at center, max.	0.02 in.	none
Compression of section (in 12 ft. height)	0.158 in.	0.155 in.

CHARACTER OF FAILURE: 1, Natco; by crushing of mortar, and crushing and shattering of tile in 2d, 3d, 4th and 5th courses from the top. See test panel No. 280 (in the machine) in Fig. 1. 2, Monarch; by crushing of mortar and shearing of tile at first joint from top. See test panel 277 (at left) in Fig. 1.

It is of interest to note that this Chicago plant, while serving mainly for the storage of tile and tools for construction work, is built to illustrate some of the various types and uses of tile. The outer walls are of the material used in exterior work, and illustrate the possibilities of decorative work by colors, shape, surface, paneling, etc. The buildings show fireproof-tile construction for columns, walls, partitions, floors and roofs; also combination tile and concrete construction, and the fireproofing of steel columns

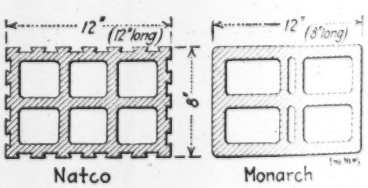


FIG. 2. CROSS-SECTIONS OF NATCO AND MONARCH TILE BLOCKS

and structural work. The tile is not covered with plastering (as it would be in ordinary work), but is left exposed in order to exhibit the various applications.

Tests of Wall Panels

In the record of the tests already mentioned, no explanation was given of the differences between the two types of blocks used: the Natco and the Monarch. Sections of these are shown in Fig. 2. In the former, when laid up in a wall and breaking joint vertically, the effective bearing is practically limited to the three longitudinal webs, as the ends and inner cross webs are not continuous in adjacent blocks. That is to say, owing to the staggering of the vertical joints, the end walls and cross webs of one block rest across the interior hollow spaces of the two blocks below. Consequently, the web or effective bearing area is less than the gross sectional area of the block. The latter type of block, however, is designed specially to have the gross area as effective bearing area; in each vertical joint, the end walls of the two adjacent blocks rest on the double cross web of the one block below.

The test panels of these two types of blocks were 12 ft. high, 3 ft. wide and 8 in. thick; but the Natco blocks were 12 in. high (8x12x12 in.) and Monarch blocks, 8 in. high (8x12x8 in.). The blocks were laid in portland-cement mortar (1:3); the horizontal joints were uniform and averaged ⅜ in. thick, and each joint was reinforced with a strip of wire mesh. The results of the tests may be summarized in the accompanying table, and Fig. 1 shows the test panel of the Natco block after failure.

The report of the testing engineer states that generally the tile wall specimens gave no signs of distress until a load well toward the maximum was reached, when slight cracking sounds were heard.* This was soon followed by longitudinal (vertical) cracks through the vertical joints, or the spalling of the horizontal mortar joint. Either of these indications was followed almost immediately by sudden collapse. The failures were generally local in character and the percentage of breakage (that is, the percentage of the broken blocks or surface to the total area of the panel) was small, so that in general the panel could be removed and set on the floor as a permanent record, as shown at the right in Fig. 1.

*The records of individual tests show, however, that in a number of cases these slight sounds (giving warning of stress) commenced with loads considerably below the maximum.

In building walls or partitions, the blocks should be laid with the interior webs vertical (as in the tests described). Tests were made, however, with the Natco blocks laid on their sides, with the voids horizontal and the flat surfaces of the blocks (instead of their cross-section areas) in contact. These gave much lower results, and in the best result failure occurred with a total load of 146,000 lb., or 1738 lb. per sq.in. of net area in compression.

Fig. 3. Cross-breaking Test of a Tile and Concrete Floor Slab (39 Ft. 6 In. Long, 24 Ft. 6 In. Clear Span)

Test of a Tile and Concrete Floor Slab

A specially interesting test, not described before, was the cross-breaking test of a floor panel of tile and concrete construction. This panel was 39½ ft. long, 2.7 ft. wide and 12 in. thick. Its construction and its arrangement in the testing machine are shown in Fig. 3. The test was made May 6, when the panel was 28 days old, and the following is an abstract of the report of the testing company.

This floor panel was built of 8x12x8-in. Monarch tile, set on one 8x8-in. end, with the openings through the tile horizontal. There were four rows of courses of tile. The two inner courses were full-

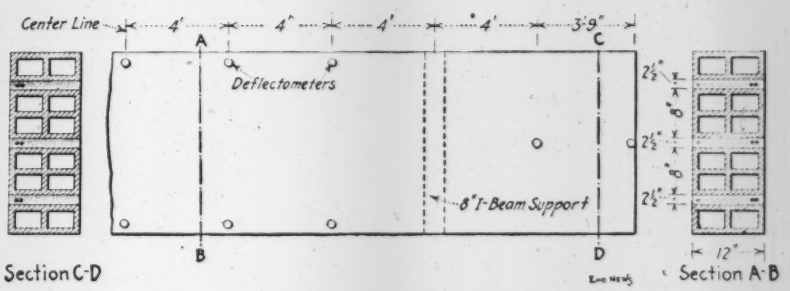


Fig. 4. Plan and Sections of Floor Slab
(The circles on the plan show the positions of the deflectometers.)

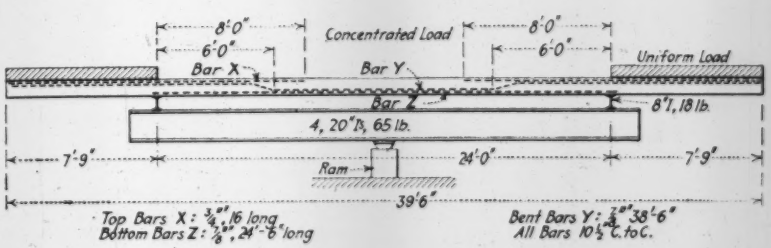


Fig. 5. Arrangement of Floor Slab in Testing Machine for Cross-breaking Test
(The dotted lines show the reinforcing bars in the concrete between tiles.)

size tile, but the tile in the outer courses were cut down to approximately half of the original thickness. The average width of opening between the courses was 2⅞ in. Mortar joints between tile were approximately ¼ in. thick, and joints were broken in each course. The reinforcing consisted of one ⅞-in. square ribbed bar laid ½ in. from the bottom of the tile between each row, and a similar bar placed ⅜ in. above the first at the center portion of the panel but bent up (6 ft. inside the supports) to about 1¾ in. from the top of the tile and extending to either end of the panel. There was also one ¾-in. square ribbed bar at either end, placed ½ in. below the surface of the tile.* The location of the reinforcing bars is shown in Figs. 4 and 5.

In order to obtain the lateral restraining effect, in this narrow panel, which would be obtained in a floor panel of the usual relative proportions, angle-iron straps were applied at the sides of the panel at each alternate joint. These straps were placed over the joints and bedded in plaster of paris, and were held in place under light tension by bolts extending across the top and bottom of the panel, as shown in Fig. 3.

The concrete was a 1:1½:3 mixture of portland cement, torpedo sand and small gravel. This material was hand mixed dry four times and then mixed by machine with sufficient water added to give a wet mixture. The mortar was a 1:3 mixture of portland cement and clean, sharp beach sand. This material was hand mixed dry three times and the mortar was made up in small quantities as used. All material was proportioned bl volume in 1- and 2-cu.ft. boxes, struck measure. The panel was built in place on the testing machine and was supported on two 8-in. I-beams placed 24 ft. apart. These I-beam supports were carried on four 20-in. I-beams, about 30 ft. long, resting on the ram or head of the testing machine, as shown in Fig. 5. The forms on which the panel was built were left in place until Apr. 22, 1912. The following are the principal dimensions of the panel:

Total length	39.5 ft.
Total width	2.7 "
Distance between supports	24.0 "
Length of cantilever sections	7.75 "
Total area	106.65 sq. ft
Area between supports	64.8 " "
Area of cantilever sections	20.9 " "

METHOD OF TESTING—This test was made on a vertical, hydraulic type of testing machine having a maximum capacity of 300 tons. In testing the panel, a concentrated load was applied at the center of a 24-ft. span and uniformly distributed loads of pig lead were placed on the cantilever sections. The center load was applied through a spherical bearing block and the two 8-in. I-beams resting on a ⅛-in. iron plate 20 in. wide. The concentrated load was applied in increments of about 3300 lb. and the uniform loads on the cantilever sections were applied in increments of approximately 2100 lb.

Deflectometers were placed at 4-ft. intervals along either side of the panel, as shown in Fig. 4, to obtain the deflections under load at these points. Extensometers were applied to the sides of the panel to determine the longitudinal shortening and elongation at the top and bottom of the panel. They were placed 54 in. apart and equi-distant horizontally from the center of the panel. The dials were graduated into 72 divisions and the observed movement of the needle from zero was recorded in divisions and decimal parts of same. The locations of the neutral axis were determined graphically. Readings of the deflectometers and extensometers were taken immediately after each increment of load had been applied.

*It will be noted that no stirrups or shear bars were used.

RESULTS OF TEST—This test was made in order to demonstrate the resistance to shear at the supports in a floor panel of this type built of 8-in. tile and without shear bars or top dressing of concrete on the upper surface. The final results of the test are shown in Table II and Fig. 6. The curves of Fig. 6 show the positions taken by the panel under the various loads. Each curve has been designated by the serial number of the load at which the deflections occurred.

The view in Fig. 3 shows the panel at the tenth load, with the arrangement of the lead pigs for loading on the cantilever sections. After the ninth load was applied, slight cracking sounds were heard. After the twelfth load was applied, hair cracks were observed in the vertical joints near the supports and also in the outside tile near the north support, and in one tile at the bottom of the panel near the center. There was no ultimate failure of the panel, but primary failure occurred at the twelfth load, due to stressing of the steel beyond its yield point. It was evident that the full compressive strength of the tile had not been developed.

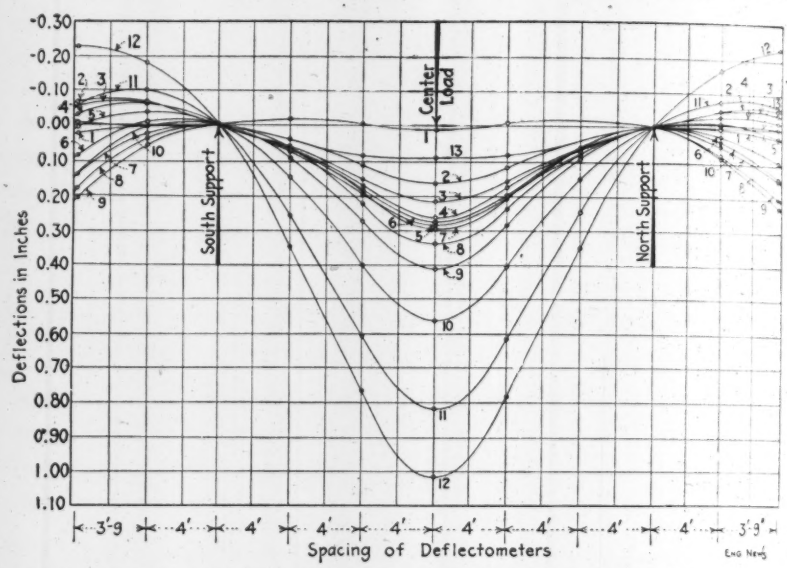


FIG. 6. DEFLECTION CURVES SHOWING THE POSITION TAKEN BY THE PANEL UNDER THE VARIOUS LOADS

(The numbers on the curves are those of the consecutive loads; see Table II.)

TABLE II. CROSS-BREAKING TEST OF TILE AND CONCRETE FLOOR PANEL (SEE CURVES, FIG. 6)

Load No.	Center Load lb.	Load on Cantilever Ends North lb.	Load on Cantilever Ends South lb.
1	0	0	0
2	3,250	2,132	2,118
3	6,981	4,264	4,255
4	10,740	6,380	6,380
5	13,489	8,522	8,489
6	16,219	10,667	10,514
7	18,953	12,788	12,764
8	21,631	14,935	14,934
9	24,364	17,058	17,078
10	28,047	19,252	19,201
11	33,443	20,994	21,063
12	37,443	20,994	21,063
13	41,443	20,994	21,063

Final results:

Concent. load at center of 24 ft. span	41,433 lb.	
Load on cantilever ends, lb.:	North	South
Total	20,994	21,063
Unif. load per sq. ft.	1,003.5	1,006.8
Deflections, maximum at center	1.0175 in.	
	North	South
4 ft from center	0.777	0.766
8 ft. from center	0.346	0.352
3¾ ft. from end	0.166	0.179
At end	0.229	0.226

A boiler seam protector now being introduced is for the protection of the circular or girth seams of externally fired boilers from the action of the fire and of the cold air currents entering when the furnace door is opened. A flat steel bar is bent to fit the curve of the boiler shell and is slotted for stud bolts. This is placed around the seam, and upon it are fitted tiles or tile blocks which are slotted to slip horizontally over the side of the bar. The tiles are held in place by their own weight and require no fastening. They cover the seam, rivets and steel bar. The device is a specialty of the J. J. Gage Boiler Girth Seam Protector Co., of Dayton, O.

Further Investigations of Puzzolan-Portland Cements

By Edward Duryee*

An improved hydraulic cement made by regrinding portland cement with tufa was suggested by the writer in an article published in Engineering News, Dec. 1, 1910, p. 596. Cement of this character has been used during the past two years in much of the construction of the Los Angeles aqueduct and with satisfactory results. Particularly gratifying illustrations may be found in several inverted siphons of reinforced concrete, 10 ft. in diameter and with heads of 60 to 70 ft. of water, that remain dry on the outside and free from cracks. This cement has also entered into the construction of the various sections of aqueduct, in lining tunnels, open canals and covered conduit, improving the quality as well as lessening the cost of construction. Some tests of the material used in the Los Angeles Aqueduct are shown in Table I.

The term puzzolan-portland cement is suggested as a correct designation of these cements, in which portland cement may be considered as an intermediate stage in manufacturing a hydraulic cement and in which the final stage consists in grinding together the portland and a natural puzzolan, thereby obtaining a product retaining the excellent qualities of early hardening characteristic of portland, as well as being made more permanent and proof against the action of ordinary as well as sea and sewage waters. The tufas heretofore mentioned are not the only natural sources of active silica; there are several classes of natural puzzolanas or colloids (mineral glues) that may be used for hydraulic cements and they fall under the following classifications: (1) siliceous animal skeletons, (2) deposits from thermal springs (tufas), (3) gelatinous deposits formed directly by the decomposition of rocks by organic acids, (4) fossiliferous deposits from algæ (diatomaceous or infusorial earth).

The chemical energy of the hydrous silicic acid is greater the more water it holds chemically combined. The above classes of rocks afford sources of amorphous silica.

In the study of this subject, a series of trial cements was made by another chemical engineer and the writer to obtain an exhibit of the comparative values of portland cement, puzzolan-portland cement, sand cement, finely ground portland and of the mixtures of puzzolanas and portland. To secure uniform conditions the same lot of portland cement was used in all the tests reported and a local diatomaceous earth called in this article Newton puzzolan was used. The same mill was used in all tests and standard methods of testing were followed. All proportioning was done by weight, the proportions of materials used in each case being uniformly alike.

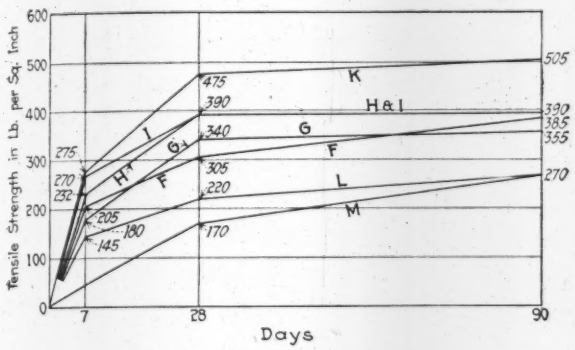


TABLE SHOWING DETAILS OF CEMENTS USED IN TESTS GIVEN IN FIG. I

Sample	Nature of the cement mixture	Fineness per cent. 200-mesh sieve	Setting of neat mixture Per cent. of water	Initial, hr. min.	Final, hr. min.
F	Straight portland cement	84	..	....	....
G	6 pts. portland+5 pts. diatomaceous earth, ground separately	85.5	36	0:50	4:45
H	6 pts. reground portland+5 pts. diatomaceous earth, ground separately	87.3	42	1:05	4:25
I	6 pts. reground portland, no puzzolan	90.5	30	0:11	4:00
K	6 pts. portland+5 pts. diatomaceous earth together	86	42	1:05	4:25
L	6 pts. portland+5 parts quartz sand, ground together	....	38	0:09	4:00
M	6 pts. hydrated lime+5 pts. diatomaceous earth	....	..	....	....

Fig. 1. Comparative Tensile Strengths of Portland, Puzzolan-Portland and Lime Mortars

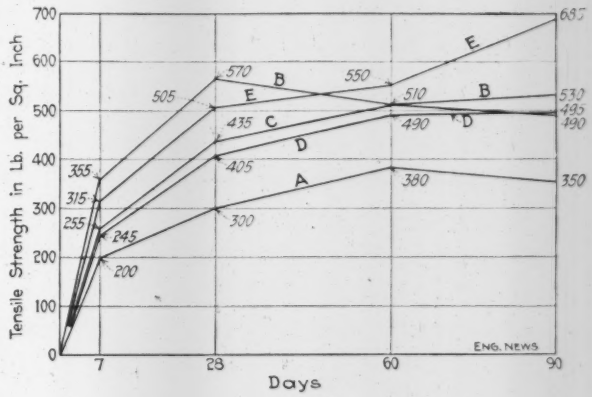


TABLE SHOWING DETAILS OF CEMENTS USED IN TESTS GIVEN IN FIG. 2 AND TABLE III

Sample	Nature of the cement mixture	Setting of neat mixture Per cent. of water	Initial, hr. min.	Final, hr. min.
A	Straight portland cement	24	2:30	6:30
B	1 vol. (38 lb.) portland+2 vol. (38 lb.) puzzolan	35	1:15	6:15
C	1 vol. (38 lb.) portland+2+vol. (41½ lb.) puzzolan	40	1:15	10:00
D	1 vol. (37½ lb.) portland+2+vol. (39½ lb.) puzzolan	30	0:50	6:00
E	½ vol. (19 lb.) portland+2 vol. (9½ lb.) puzzolan	40	1:00	6:00

*All puzzolan = diatomaceous earth.

Fig. 2. Tensile Strengths of Various Puzzolan-Portland Mortars

Fig. 1 represents the tests made on one set of the seven different mixtures, described in the table below the figure. The cements, the properties of which as regards setting and fineness are given also in the table, are either plain portland or a mixture of portland or lime with puzzolana. The briquettes, tested in tension, are made up of one part (by weight) of the mixed cement and three parts sand. No artificial heat was used in preparing the diatomaceous earth, the pieces as dug being broken into small sizes and exposed to the air to dry before grinding. The material must be sufficiently dry to permit of its being ground very fine. Fig. 2 represents the comparative strengths of certain similar puzzolan-portland cements.

A qualifying test of any puzzolana for

*Chemical Engineer, 122 Occidental Boulevard, Los Angeles, Calif.

TABLE I. TESTS OF LOS ANGELES AQUEDUCT PUZZOLAN-PORTLAND CEMENT

Setting Time, Initial, hr. min.	Setting Time, Final, hr. min.	Per cent. water	Tensile Strength Lb. per Sq. In. (1 cement to 3 sand) 7 days	28 days	3 mo.	6 mo.	12 mo.	Fineness, 100 m.	Fineness, 200 m
3:30	7:45	10.2	255	370	484	555	....	99	92
....	....	....	273	434	480	580	593	....	....
2:15	5:45	....	231	376	477	....	....	99	90

Note.—The cements tested above were 50% by volume tufa and the results were averages of tests of three different laboratories working on different samples taken at different times

use in cement making is its solubility in a standard alkaline solution; the active silica will go into solution. The writer's determinations of the active silica in the diatomaceous earths used in the cements referred to in this paper showed in one case 22.6% and in another 60% active or "soluble" silica. Another determining factor is that the puzzolana shall unite with lime and show hydraulic properties, as in Sample M (Fig. 1), in which the diatomaceous earth and lime mixture showed a strength in water in 28 days, three times that of lime mortar, and in 90 days five times as strong as lime mortar. The diatomaceous earth or lime alone have no strength in water. The well known chemical and physical characteristics of diatomaceous earth, its high silica content and the active colloidal character of its silica, together with its porous absorbent nature, facilitate the combination of its silica with the lime in the cement. The combined as well as the added water promote the combination, and the basic lime combines with silica and becomes an element of strength as opposed to one of danger and decomposition as is sometimes the case with the use of ordinary portland cement. All the puzzolanas have this qualification of combining with hydrated lime, the product being ordinary puzzolan cement which becomes very strong in time, but more slowly than do the new puzzolan-portlands. This grinding with portland has shown a remarkably improved product, greatly superior to any mere mixtures obtainable even with the same materials in the same proportions but lacking the essential condition of being ground together.

An illustration of the use of an inert material is shown in Mixture L (Fig. 1), in which the same proportions of cement and sand were used and these were ground together by the same treatment as followed in Mixture K, but the tests indicate that quartz has not the hydraulic action with cement that characterizes diatomaceous earth when treated according to the process advocated.

Portland cement is an unstable basic silicate and aluminate of lime containing the maximum proportion of lime that can combine with the silica, alumina and ferric acids at the high temperatures of a kiln, or approximately 2800° F. A commonly accepted formula reads, $3CaOSiO_2 + 2CaOAl_2O_3$. It may not be generally understood that these high proportions of lime cannot be appreciably lowered in the process of manufacturing ordinary portland cement, for if a lower lime mixture is burned it will either melt or, on exposure to air, the clinker will "dust," that is, disintegrate to a powder having but little cementing value. The present proposal therefore is to add active silica to the cement after it has been burned and in such manner as to facilitate its combination with the excess of lime that is liberated when water is added to it. The writer has found that satisfactory results are obtained by mixing about equal proportions of diatomaceous earth and portland cement, then grinding them together to a fineness of 90% passing a 200-mesh screen. The resulting mortars made in the usual manner of 1 part of this cement to 3 parts sand (Sample K, Fig. 1) show great superiority to any other combination. Curves G and H (Fig. 1) show that even the same materials in the same proportions when merely mixed fall far short in strength of the product shown in K. Curves F and I show the same comparative strength of portland cement alone, F being ordinary portland and I being reground portland. Curve L is an exhibit of sand-cement made by grinding quartz and portland cement together.

The puzzolan-portlands usually do not differ greatly from ordinary portlands in setting times. The reground cements that did not contain infusorial earth were quick setting and efforts to retard the setting time of Sample L by adding gypsum failed. No setting test of Sample F was made, but the usual time of this brand of portland is 2 hr. 30 min. for initial, and 5 hr. for final set. The sand mortars of Samples K, G, H and L required 11.5% water and Samples F and I took 9.5% water, puzzolan-portlands taking more water than ordinary portlands both in neat and sand mortars.

Comparison of Curves F and I with Curve K shows that even portland or reground portland cements did not produce so strong mortars as cement containing only about half as much portland cement when prepared as proposed. Cement K made stronger mortars than the sand-cement mortar from L. Hydrated lime with diatomaceous earth showed hydraulic strength in one and three months' periods. The product obtained by grinding together portland cement and diatomaceous earth as described secures far better results than any other mixture or method tried.

Taking up now the tests shown in Fig. 2, the diatomaceous earth used in preparing Samples B, C and E was dried with artificial heat to drive off any excess moisture, but not to a red heat, while the diatomaceous earth used for Sample D was merely dried in the air by exposure to the sun's rays for three hours. All the samples ground satisfactorily and the results showed that air drying was sufficient. All the samples were prepared with the same portland cement as was used for Sample A, and this sample was saved for a standard of comparison without mixing or grinding it. The standard for fineness of grinding all the samples was 90% passing a 200-mesh screen. All the tests were conducted under standard and uniform conditions. The Curve K (Fig. 1) and Curves B, C, D, E (Fig. 2) show success in converting the basic portland cement into an acid puzzolan-portland cement, the latter containing an excess of active colloidal silica in condition to unite with all the lime given off in the ordinary process of setting of portland cement and when this cement hardens there is no free hydrated lime to dissolve out with water or be attacked by sulphate salts of sewage, alkali or sea waters. Following are some typical analyses:

A comparison of the analyses of the diatomaceous earth and tufa shows the superiority of the diatomaceous earth both on account of its higher silica and also for its lower alumina content. In the above diatomaceous earth a test showed 60% active silica in the total of 75.9%. This is not a pure diatomaceous earth, but it is the quality generally used in making these cements and with good results. All but one of the cements referred to in Figs. 1 and 2 were made with this grade of earth. The cement tested for Curve E in Fig. 2 was made with a purer earth, the purer grades of infusorial earth show from 82 to 90% silica and these being of lower specific gravity require to be used in smaller

TABLE II

	Portland cement	Puzzolan-Portland cement	Diatomaceous earth	Tufa
Lime	62%	47.1%	7.65%	1.16
Silica	22	35.5	75.9	67.1
Alumina and ferric oxide	9	9	5.9	15.6
Balance, magnesia, alkali and ignition loss.				

TABLE III. DURYEE'S PUZZOLAN-PORTLAND CEMENTS IN SEA WATER BRINE

(Tensile strength in Lb. per Sq.In.)

Water	Sample	No.	7 Days Neat sand	7 Days 1-3	28 Days Neat sand	28 Days 1-3	3 Months Neat sand	3 Months 1-3	6 Months Neat sand	6 Months 1-3	Remarks
Fresh	Ordinary Portland	A	541	205	654	310	658	332	612	385	The 3 months sand on B, E, D and ordinary portland were all higher than those in fresh water, but the record was lost.
Sea	Ordinary Portland						761		811	316	
Fresh	Duryee	B	250	270	244	476	358	418	377	531	
			219				622		565	641	
Fresh	Duryee	C	219	201	272	334	259	414	391	460	
Sea							520	478	476	808	
Fresh	Durvee	E	224	148	389	488	501	465	491	523	
Sea	Durvee	E					745		676	808	
Fresh	Durvee	D	265	177	304	313	341	441	398	405	
Sea	Duryee						446		467	498	

Footnote: The test sea water was concentrated fourfold by boiling down ordinary sea water. All briquettes were first left one month in fresh water, then one-half of them were put in sea water.

All the portland cement used in the above was from one sample of ordinary portland cement, the same as Sample A, but B, C, D and E were separate grinds of this portland with puzzolan mixtures of varying proportions as made by Duryee for comparison.

proportion by weight in making the mixtures, as indicated in the table.

The specific gravity of portland cements was 3.1, of the reground portland Curve I (Fig. 1) was 2.98, and of the cement of Curve K was 2.64. If desired, the gravity of a cement can be lowered by using pure infusorial earth and also in larger proportion, and for building purposes where light-weight construction, together with improved fireproofing qualifications, are a consideration it will be found desirable to do this.

Diatomaceous earth is composed of the fossils of siliceous, microscopic water plants or algæ and deposits of this character are widely distributed. In this country they occur in California, Maryland, Virginia and New York states. This infusorial earth sometimes contains 150,000 siliceous fossils to the cubic inch and its physical as well as chemical character, as it is remarkably absorbent as well as adsorbent and a nonconductor of heat and runs exceedingly high in colloidal silica, make it remarkably suitable for the purpose under consideration. It forms a spongy, viscous medium for holding the hydrated lime liberated when water is added to cement till the silica can combine with it chemically.

Tests in Sea-water Brine

It has been mentioned that when portland cement is made into mortar with water considerable hydrated lime is formed which is soluble in water and besides it readily combines with the sulphuric and hydrochloric acids occurring in combination with soda and magnesia in sea water and sewage. In this puzzolan-portland cement the colloidal silica present in excess combines with this lime to form the same salt of lime as is formed by the silica originally combined in the cement.

The series of tests shown in Table III were made of the writer's cements in an independent laboratory by another tester. The samples of cements used were the same as those illustrated in Fig. 2. The results are remarkable and indicate that while the sand mortar of ordinary portland began to lose strength in brine in six months, on the contrary, all the sand mortars of puzzolan-portlands improved in brine and were stronger in it than in fresh water.

Suggestion as to Weight of Barrel

It has been customary in the use of puzzolan-portland cement on the Los Angeles aqueduct to proportion the constituents by volume, at one plant the volume of tufa in the product being 50% and in another 60%. This product is sacked in 1-cu.ft. capacity sacks and four of these sacks are used as a barrel; the weight of this barrel of cement is about 325 lb., while the weight of a barrel of portland cement is 376 lb. net. The laboratory tests of all these cements are made with mortars proportioned by weight and it seems that the barrel of puzzolan-portland cement should be made to weigh the same as the portland barrel, without regard to its volume. In preparing specifications for these cements it is recommended that this provision should be made.

A 2400-Volt Direct-Current Electric Railway at Butte, Mont.*

The Butte, Anaconda & Pacific Ry. has decided to convert its steam road between Butte and Anaconda to electric traction. There is about 30 miles of single-track main line with a total single-track mileage of about 114 miles including sidings, yards, smelter tracks, etc. Only about 90 miles of this trackage will be converted at present, the untouched portions comprising mine tracks, minor sidings, etc. Sixteen miles of the main line is operated jointly with the main-line service of the Chicago, Milwaukee & Puget Sound R.R. The traffic consists principally of hauling copper ore, mine supplies, lumber, etc., the amount in both directions aggregating some 5,000,000 tons per year. The maximum grade against load is 0.3% with 1% maximum against the returning empty cars. The heaviest train will consist of 50 loaded ore cars weighing 3400 tons.

Current will be supplied to locomotives from a No. 0000 copper wire, with a flexible 11-point catenary suspension. Over some of the difficult sidings, smelter tracks, etc., there will be direct suspensions. Side-trackage or cross-span construction will be used to suit local conditions. At one point it is necessary to span twelve tracks, in which case a third pole will be set between the eighth and ninth tracks. The overhead conductor will be reinforced between the two sub-stations by a 1,000,000-cm. positive cable. A No. 0000 negative return feeder will also be run on the trolley poles; one No. 0000 bond will be installed across each rail joint with cross bonds between rails every 1000 ft., each of which will be connected to the negative feeder.

The power supply will be secured from the Great Falls Power Co. at 102,000 volts, 60 cycles. There will be two 2400-volt sub-stations, one at Butte and the other at Anaconda, 26 miles apart. Each will contain two 1000-kw. synchronous motor-generator sets, each set comprising two 500-kw. 720-r.p.m. compound compensated commutating-pole 1200-volt generators, insulated for 2400 volts and operated in series. They will be direct-connected to a single 100-kw. three-phase 60-cycle 2300-volt synchronous motor. These motor-generator sets are guaranteed to stand an overload of 200% for five minutes. The service is expected to require the operation of both sets for most of the time. Each feeder circuit and generator circuit will be protected by a 2400-volt direct-current aluminum-cell lightning arrester.

There will be 15 freight locomotives, each weighing 75 tons, the weight being all on eight 46-in. drivers. The frame is articulated and carries four 1200-volt commutating-pole twin-gear motors, operated two in series. The motors are insulated for 2400 volts and forced ventilation is used. A roller pantograph trolley collects from the overhead line. Each locomotive will give a continuous tractive effort of 25,000 lb. at 15 miles per hour, and will safely develop 45,000 lb. in starting but for periods not exceeding five minutes. For the operation of the contactors, headlight, air compressor and cab light a dynamotor will be used having two windings, one for 1800 volts and the other for 600 volts, combined in series for main-line connection. For the heavier freight trains two locomotives will be needed.

There will be two passenger locomotives and these will be duplicates of the freight type, except for the gear ratio. The passenger locomotive is geared for a maximum speed of 45 miles per hour on tangent level track with three coaches. Eight local passenger trains will be operated per day. The passenger cars will be lighted from the 600-volt circuit of the dynamotor and heated from the 2400-volt trolley circuit on the locomotive, using 600- and 2400-volt train lines.

*From an article by J. J. Linebaugh, General Electric Co., Schenectady, N. Y., "General Electric Review," August, 1912.

The Population of the Isthmian Canal Zone, taken between Feb. 1 and March 31, 1912, has just been published. The total number of persons enumerated was 71,682, of whom 8661 were employees of the Canal Commission and the Panama R.R., and 211 of contractors, who, while employed in the Zone, resided in Panama and Colon, which placed the total population of the Canal Zone, embracing the territorial scope above described, at 62,810. Of that number 19,413 were white, 31,525 black, 10,323 mixed, 521 yellow, 378 Hindoos, 2 Filipinos and 648 reported as "Indians." The last census of the Zone prior to this one, taken June 23, 1908, showed a population of 50,003, so that in the interval since then there has been an apparent gain of 12,807 inhabitants. It is strange to note that classified by citizenship Great Britain leads in the present census with 30,859 persons. The United States, which is second, has 11,850, 9770 of whom were born in the United States. The report shows that the total number of employees of the Canal Commission and the Panama R.R. at the time of the enumeration was 41,174, of whom 32,513 resided in the Canal Zone and 8661 in Panama and Colon. The number employed by the Canal Commission was 33,241, and by the Panama R.R. 7933.

The Physical Valuation Department of the Nebraska State Railway Commission*

The Physical Valuation Department of the Nebraska State Railway Commission was organized to find the physical value of the properties of all steam and electric railways, telephone, telegraph, and express companies, the transportation departments of stock-yard companies and any other public utilities as required.

The department is virtually a subcommission of the Railway Commission, being governed in all cases by the rulings and instructions of the latter. Yet its work is largely independent of the regular business of the Commission, and it really is a board of experts, which gives its entire time and labor to valuation work. The utility companies have been very free in coöperation and have furnished all the required information to assist in securing fair and just results. On the other hand, the department has endeavored to deal with them in a uniformly courteous and sincere way.

The law authorizing physical valuation does not specify the purpose for which the valuations may or shall be used, but it specifies that a value shall be found representing the reproduction cost at current prices of material and labor, treating the properties as being entirely new. Also a present value of the same properties is to be found in a condition as of the year in which the valuation is made.

The physical value may be used as a foundation for computing various other values in determining taxation, capital or earnings, and selling price. The various detailed items may also be used in computing a reasonable compensation for service. This physical value represents the actual cost in money to provide, assemble and install in place the various physical factors of a completed plant or property and to prepare it entirely for operation. It includes certain nonphysical charges, which are essentially inseparable parts of construction cost, covering (1) expenses incident to designing and testing the construction, equipment, etc., (2) administration expenses during construction, including superintendence, inspection, accounting, legal expense, incorporation fees, etc., (3) taxes, insurance, printing, postage, rent, etc., during construction and prior to operation, and (4) a reasonable interest on the actual cash investment for one-half the total construction period.

The preliminary expenses of promotion, financing, the discounts on securities, the brokerage and such expenses, the administration charges not applicable to construction yet necessary for securing patronage and organization into a going concern are included, together with a reasonable promotion profit and compensation for the risks of capital, for expert engineering in the examination of country and determination of route, and for deficiencies before the plant or property is placed on a paying basis. Arrangement of the various accounts of the valuation work follows closely the classification used by the Interstate Commerce Commission.

In the three years' existence of the department the physical valuation of all steam railroads and of the transportation facilities of stock yards within the state has been completed. These were reported to the Railway Commission from time to time, the last one being turned in about Nov. 1, 1911. A revaluation as of date July 1, 1911, is now under way. Under date of July 1, 1911, the department has completed the initial valuation for the five express companies in the state, and also for the four electric interurban lines.

The valuation of telephone properties has been found a difficult problem by reason of the large number of companies to be valued and the widely different nature of their plants. Much correspondence has been necessary to get in touch with each company and to point out the specific information necessary to be furnished to the department. With very few exceptions, the companies have assisted materially in the valuation work and have coöperated in every way in securing the necessary information. The total number of telephone companies subject to examination (exclusive of those associated with the Lincoln Telegraph & Telephone Co. and the Nebraska Telephone Co.) is 285. Of these, 235 properties have been valued, 25 are in process of valuation, and 25 remaining have not turned in their reports.

Following is a brief summary of the method of arriving at findings reported. Uniform blanks were furnished to the various utilities for reporting a complete inventory and setting out in detail accounts, kind and amount of each and every item. While these blanks were being filled out by the respondents, various members of the department prepared a preliminary estimate and gathered a complete inventory of the properties, viewing every mile of railroad and electric line, the stock-yard properties and many telephone plants, taking complete detailed field notes at each inspection.

Railroad Valuation

The work of the department has been divided into three general classes in dealing with the railroad valuation: (1) Land, (2) roadway and buildings, (3) equipment. An exhaustive study was made on land values, current prices of labor and materials were secured from various manufacturers, contractors, etc., and an extended and detailed investigation was completed, covering the life and value of equipment.

Securing land values alone was an enormous task. Information was secured from more than 500 responsible real estate men, bankers and merchants. County records were examined and more than 3000 actual transfers of farm land were taken therefrom, together with a large number of transfers of properties in towns and cities. Access was had to approximately 5000 transfers gathered by the various utility owners. A complete inspection was made of all rights-of-way and local lands, and a reasonable amount was allowed for severance and other property damages. Assessed values were given due consideration, as was also the findings shown in the 1910 census report. All these values were tabulated in detail, and from them the final unit value was derived and used in the reported valuation. A special investigation of land values in the cities of Omaha and South Omaha was made, covering a period of approximately one year's work and resulting in a complete and detailed statement of all important land transactions occurring there subsequent to 1904. The work on land values has not ceased, but information is being continually added to that already secured to keep it up to date. The extent of the work in land values may be realized by considering that the valuation covers more than 160,000 acres and required the study and tabulation of land values in every county in the state with a comparison of figures for land as sold, assessed, and as valued in the 1910 census, together with an inspection of the entire 6074 miles of main-line roadway in the state, and an investigation in over 900 of the more important towns and cities on the various lines of railroad.

The land was involved in rights-of-way, station grounds, terminals, and other holdings of the seven principal railroads. It comprised an area of approximately 120,000 acres, with a total market value of approximately $25,000,000 as determined by the department and $27,000,000 as estimated by the railroad companies. Placing values on so large an acreage so widely scattered and surrounded by every varying condition and value has required unlimited patience, untiring labor, and exercise of careful judgment. It involved the study of topography and use of land, character and productiveness of soil, climatic conditions, density of population, and a close observation of various enterprises and developments.

The valuation of roadway and buildings included an immense amount of detailed investigation and required a familiarity on the part of the department with each item going into the various and multitudinous articles and structures used. A careful estimate was made of all quantities of earth and rock in the grading, the amount and kind of clearing, and grub-

*From information furnished by C. H. Gerber, Principal Assistant Engineer, Valuation Department, Nebraska State Railway Commission, Lincoln, Neb.

bing along the rights-of-way. Prices were assigned for these items based on contractors' bids and on actual prices paid, with consideration given to the conditions existing in the various portions of the state. Prices of rails, ties and track appliances were secured from manufacturers and dealers, and the cost of laying track, placing ballast and surfacing was determined from actual costs, covering many miles of construction for similar lines in central and western states. Bridges and culverts were inspected and prices were determined for piling, stone, timber, steel, concrete and pipe, together with the cost of labor for placing each item. Buildings and miscellaneous structures, including coal chutes, water tanks, etc., were shown in detail by inspection and values were assigned from actual cost of similar structures.

The thoroughness of the department's work is verified by the fact that two of the larger roads have stipulated the department's valuation as being correct and have admitted a considerable reduction in their own estimate and only one road has contested the Valuation Department estimates.

Valuation of Telephone Companies

In making the telephone valuations lack of time and money has manifestly made impossible inspection of all the telephone properties in the state, but members of the department have gone over portions of nearly all properties. The inventories of the company have been found to be extremely accurate and complete, as a rule, so that the department with a small amount of checking has been able to accept these reports and by applying average unit costs and by considering the age of the plant and its general condition, has derived reproduction and first values.

Telephone cost data were collected from every available source. Appraisals made in various parts of the United States were carefully studied and actual costs to the company and this state were analyzed, classified and finally sifted down to average units, representing, as the statute specifies, the average cost of labor and material for the year ending July 1, in which the appraisal is made. Owing to the extent of the two largest properties in the state, it was thought best to confer on unit costs before inventory reports were secured from the companies rather than having to argue this matter before the Railway Commission, after separate valuations had been returned.

Cost of Valuation, Etc.

There has been some criticism of delay in completing the 1909 railroad valuation, but this comment originated with persons unfamiliar with the work of the department. The seeming delays have been well used in securing every bit of available data and in carefully checking and rechecking the work. Nearly two years elapsed before the department received the last full detailed report from the railway companies, and after these were received, it required considerable time to investigate, analyze and tabulate the items. Another cause for delay is found in the joint request of all the railroad companies that no final decree should be entered or valuation adopted by the Commission on any of the cases until the evidence was presented by all of the respondents, since such final decree or adoption in one case would necessarily preclude any variation on questions common to all properties. As a matter of fairness, this request was granted.

The aim of the department has been to make the initial valuation as nearly correct and complete as human effort could, since it will be used as the basis for subsequent valuation, and because of a desire to reach a result which could be defended before the Commission and before higher courts. Consequently an extended time was taken, and each detail fully analyzed, and much information secured from outside sources. For instance, in the single item of bridges, detailed information was procured covering 38 bridges from 25 different sources, all over the United States, in order to arrive at a proper average cost of labor and material necessary for reproduction of such structures. As another instance, the track inspection alone took nearly eight months, but the field notes secured show every post, sign, crossing, cattle guard, fence, telegraph line, all the ballast, rails, ties, angle bars, bridges, buildings, and every item in place on the right-of-way, with the result that the department has been able to check up every item reported by the railway companies and to find and correct errors and omissions in the reported figures.

The actual cost of the valuation work has been very low, in comparison with costs in other states. The initial valuation of railroads in Michigan cost $75,000, and in Minnesota, $70,000. The New York, New Haven & Hartford R.R. Co. has spent $215,000 in securing a valuation on its property. The City of Cleveland, Ohio, alone has spent nearly $127,000 for an appraisal of real estate for taxation purposes. The State of Wisconsin has spent $11 per mile and the railroads working joining with the state have spent $22 per mile in addition. It cost the State of Washington $13 per mile for its railway appraisal. The first appropriation of $40,000 in Nebraska covered the first two years' work, and was practically all expended for the valuation of railroad and stock-yard properties. The other work done in these two years nearly offsets the time required to complete the railroad and stock-yard valuations in 1911. This gives a total average cost of $6 per main track mile.

The department has been able to render a limited amount of service to the State Board of Equalization and to several local county assessors by furnishing detailed valuations for several lines in various localities. Considerable information has been furnished at various times in connection with the regulation of public utilities.

Personnel of the Department

The chief engineer in charge of the entire work of valuation is E. C. Hurd, who has had large experience in the construction of railroads, canals, dams, drainage systems, city improvements, telegraph and telephone properties, electric railroads, etc., and has further acted in a consulting capacity for banking interests. C. H. Gerber, the principal assistant engineer, has devoted his time largely to the valuation of roadways and buildings of the railway and electric lines. He has had long experience in mill and mining engineering and in railway construction, besides being engaged for four years in the chief engineer's office of the Union Pacific Ry. on work covering statistics, costs, and data relative to reconstruction and projected lines, work which required complete and comprehensive investigation into details.

E. J. Kates has been in direct charge of the work covering equipment and machinery, which two items include all locomotives, cars, steam shovels, plows, pile drivers, wreckers, derricks, etc., and all tools, machinery and power appliances in the shops. Mr. Kates has had experience in railway-shop work. He is also chairman of the Equipment Values Sifting Committee, representing an association of the Central Western States, in which capacity he receives the results of all investigations made by the other states in the association in regard to equipment valuations, depreciation, etc., so that he has probably the largest fund of information in existence on this subject. In the investigation of the life of railroad equipment he has traced the history of over 15,000 freight cars, several thousand passenger cars, and several thousand locomotives from the time of their construction to the time of their discontinuance. The result is a series of tables showing the annual depreciation of equipment based on actual facts, instead of opinions or estimates.

E. W. Reed was appointed in 1909 to take up the work of valuing land. He is a lawyer who has held various civic offices and has given special study to matters of real estate valuation. The special investigation of land values in Omaha and South Omaha was made by W. G. Ure, who has been a resident of Omaha for 22 years and active during this entire time in real-estate dealings. He has also been a public official in services such as County Commissioner, member of the Board of Tax Equalization, Treasurer of Douglas County and Treasurer of Omaha, etc.

The Cherry Creek Flood, Denver, Colo.

By Charles W. Comstock*

On July 14, 1912, Denver, Colo., was the scene of a violent and destructive flood of short duration. This flood has been the subject of many incorrect and grossly exaggerated reports in the daily press, most of which have been devoted wholly to the sensational features of the occurrence to the almost total neglect of the underlying facts. Such statements as have appeared relative to the quantity of water discharged or the intensity of the rainfall have emanated from the excited imaginations of untrained observers.

However, there are available sufficient numerical data and authentic information to permit the preparation of an account which may interest the engineering profession.

Cherry Creek, in which the flood discharge occurred, flows into the South Platte River in the center of the city of Denver. It is an extremely flashy stream of the kind peculiar to the plains areas of the semi-arid region. It rises to the south-southeast of Denver, flows north for two-thirds of its course, thence northwest to its junction with the South Platte. The watershed is 55 mi. long and the total drainage area 425 sq.mi. The greatest width of the basin is 15 mi., at a point 20 mi. from Denver. From there it narrows rapidly toward the mouth of the stream. The upper 35 mi. of the basin has a fairly uniform width of about 9 mi. Throughout its length the stream channel occupies approximately the center line of the drainage basin. There are no mountainous areas within the drainage area and the slopes are gentle over the greater part of the basin. There are a few rocky and precipitous areas, but these form a small proportion of the total. The highest point reached by the drainage area has an altitude of 7700 ft. above sea level. The mouth of the creek is at altitude 5175. There is no forestation worthy the name. Most of the area is covered with sage brush and prairie grasses, though there are several thousand acres of cultivated lands in the lower part of the valley.

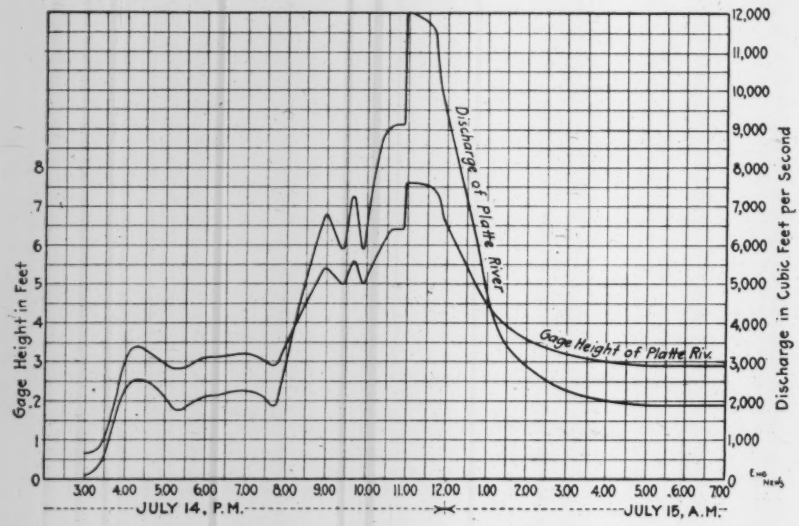

Gage Height in Feet
Discharge in Cubic Feet per Second
Discharge of Platte River
Gage Height of Platte Riv.
JULY 14, P.M.
JULY 15, A.M.

Fig. 1. Rainfall at Denver and Gage Heights and Discharges of the South Platte River, July 14-15, 1912

The snowfall in this drainage area is light and there is very little winter runoff. Throughout the greater part of the year the flow in Cherry Creek at Denver is a mere trickle, often less than and seldom exceeding 1 cu.ft. per sec. The upper part of the stream carries more water, but this is diverted by the irrigators above the city, or sinks in the deep sand bed through which the stream flows for many miles. During the summer the usual condition of the stream bed for miles just above Denver is such that one must dig several feet to find even moist sand. It is only during those torrential storms which throughout the West are known as "cloudbursts" that Cherry Creek really becomes a stream in the strict sense of the word.

Rainfall and Discharge

On July 14, rain began to fall in Denver at 3:25 p.m. Between that time and 6:30 p.m., when the rain ceased, the total precipitation was 2 in. The accumulated depths for 5-min. intervals are shown in the following table.

Accumulated Depths of Rainfall at Denver, Colorado, July 14, 1912

Time	Depths in inches
3:25 p.m.	0
3:34 p.m.	0.01
3:39 p.m.	0.32
3:44 p.m.	1.19
3:49 p.m.	1.52
3:54 p.m.	1.92
3:59 p.m.	1.57
4:04 p.m.	1.72
6:30 p.m.	2.00

The excessive rate of precipitation began at 3:34 and ended at 4:05. During the second 5 min. of this storm .78 in. of rain fell. At this time it was impossible to distinguish the outlines of windows in buildings across an 80-ft. street. This statement has been made by several creditable persons who noted the fact independently. The rain had the appearance of a nearly opaque curtain drawn in front of the observer.

Fig. 1 shows the curve of rainfall at Denver for the 3 hr. of the storm, and also the curves of gage heights and discharges of the South Platte River at a point about 1000 ft. below the mouth of Cherry Creek, for the same period. The discharges are estimated from an extension of the rating curve for the river channel at this point and are liable to important errors from two causes—first, because the flood wave was very short; second, because the unprecedented high water must have materially altered the channel.

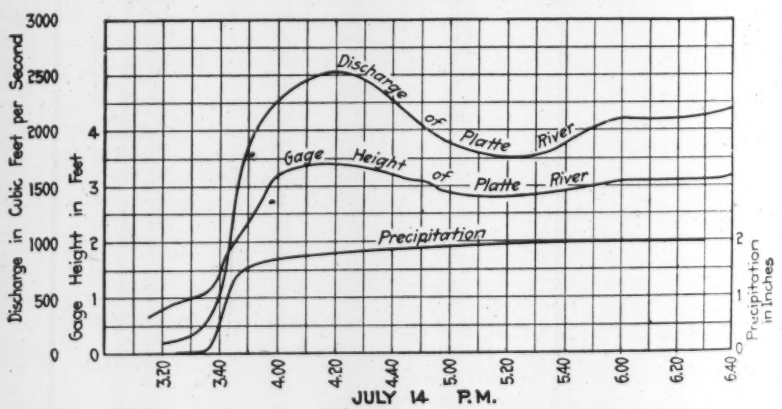


Fig. 2. Gage Heights and Discharges South Platte River, at Denver, July 14, 1912

The following table of discharge measurements shows the changes which occurred during and after the high-water period.

*State Engineer, Denver, Colo.

TABLE OF DISCHARGE MEASUREMENTS

Date 1912	Area of Section Sq.ft.	Mean Velocity ft. per sec.	Gage Height ft.	Discharge cu.ft. per sec.
July 1.....	439	4.31	2.95	1893
July 8.....	216	2.48	1.32	536
July 15.....	448	4.28	2.88	1915
July 26.....	326	4.99	1.25	1628

The measurements on July 15, the day following the flood, shows that there was no important permanent change in the channel, although it is not improbable that it was scoured out during extreme high water and filled in again as the river fell. Between the 15th and the 26th a very decided change occurred. For the same gage height the area of the section increased by 50%, and the mean velocity doubled, thus multiplying the discharge by three. This is readily explainable by known changes in the river channel. For many years a low dam, built to divert water into the Farmers' and Gardeners' Ditch, has existed in the South Platte River about a quarter of a mile below the gaging station. This produced some back water, decreasing the slope of the water surface and thus the velocity. The dam was destroyed by the flood, and the unusual discharge of the next few days cleared out the river channel and increased the surface slope.

Fig. 2 shows the curves of gage heights and discharges of the South Platte River at the Denver gaging station for the afternoon and night of July 14. The maximum discharge of 12,000 cu.ft. per sec. shown by this diagram has been objected to by some local engineers as probably too great. On the other hand, one experienced hydrographer who observed the progress of the flood with great care has estimated the maximum discharge at 14,000 cu.ft. per sec.

It will be noted that during the first three hours the rise in the river followed very closely the local precipitation. When we consider the large area of street pavements, house roofs and other impermeable surfaces, this result is to be expected. Following the period of excessive rainfall there was a slight fall in the river, after which the discharge remained nearly constant for 3 hr. In the next hour the river rose 2.50 ft. This probably marks the arrival of the run-off from the excessive rains which fell some 20 mi. above Denver in the Cherry Creek valley. Following some oscillations of about ½ ft., the gage rose rapidly to 6.40, where it remained for a few minutes, and then shot up to 7.60, indicating an almost instantaneous increase in discharge of 3000 cu.ft. per sec. This abrupt rise was due to the failure of a pile bridge across Cherry Creek about 4 mi. from its mouth. During the early hours of the flood, large quantities of drift floated down the creek and lodged against the bridge, backing up a large volume of water in the low lands above. This was suddenly released by the bridge failure shortly before 11 o'clock, with the result shown on the diagram.

Had it not been for the temporary backing up of the Cherry Creek water by the bridge at York St., it is probable that the maximum discharge of the river would not have exceeded 10,000 cu.ft. per sec. If it be assumed that 1000 cu.ft. per sec. came from the South Platte exclusive of Cherry Creek, the latter supplied 9000 cu.ft. per sec., or 21 cu.ft. per sec. per square mile of drainage area.

Unfortunately, we have no means of knowing over what area the rain extended, as there are no precipitation stations, other than Denver, in the Cherry Creek valley. It is certain, however, that the very intense precipitation did not extend to the entire valley. Thirty-five miles above Denver is located the Castlewood reservoir. It is formed by a dam across the creek and intercepts the run-off from 200 sq.mi. of the Cherry Creek watershed above altitude 6250. The area of the high-water line of this reservoir is 175 acres. On July 14 the reservoir was not full and the water area was, therefore, something less than this. The total effect of the rainfall of July 14 and 15 on the water level in Castlewood reservoir was to raise it 3 ft. This indicates something less than 500 acre-ft. total run-off from the drainage area above the reservoir.

The total discharge of the South Platte River at Denver between 3 o'clock p.m., July 14, and 6 o'clock a.m., July 15, was 5000 acre-ft. Of this about 3800 acre-ft. came from Cherry Creek. This is 17 acre-ft. per sq.mi. of the drainage area below Castlewood dam. The maximum rate of flow was 40 cu.ft. per sec. per sq.mi. of that area.

FIG. 3. DESTRUCTION OF BRICK STORM SEWER BORDERING CHERRY CREEK, DENVER

DAMAGE CAUSED BY FLOOD

The damage caused by this flood has been variously stated from half a million to three million dollars. It is probable that the lower figure is nearer the truth, though it seems unlikely that the amount will ever be accurately known. Most of the damage, in a financial sense, was to stocks of merchandise stored in the basements of warehouses near Cherry Creek in the lower part of the city. Damage of this kind was suffered by a large number of firms and since there was no insurance these people will have no occasion to make public statements of their losses.

There was, unfortunately, some loss of life among the poor people who made their homes on the low ground near the junction of the two streams. The number of lives lost is unknown to the writer, and there is some uncertainty even in the minds of the city authorities who have made special efforts to account for all persons known to have lived in the bottom lands.

The water, gas and telephone services suffered some interruptions, but no estimates of the losses suffered have been given out by the operating companies. Except for a short time during the heaviest rainfall there was no appreciable interruption in the street-car service, though some re-routing of cars has been necessitated by damage to one of the Cherry Creek bridges.

The most conspicuous damage was done to city property immediately adjoining the creek. About six years ago the city of Denver, with a view to rendering useful a considerable area of ground

theretofore subject to overflow, and at the same time improving the appearance of a part of the city, limited and defined the channel of Cherry Creek by constructing a reinforced-concrete retaining wall on each side of the creek for a distance of about three miles. On the north-east side of the stream was constructed a driveway, called Speer Boulevard, and along this drive the ground was terraced and parked in such a way as to make an attractive street, where before had been waste dumps and bottom lands overgrown with weeds. The channel thus defined had a uniform width of 80 ft. and a depth of 8 or 9 ft. below the top of the wall. The average grade of the creek bed was about 0.5% and the carrying capacity when full to the top of the wall should have been from 12,000 to 13,500 cu.ft. per sec.

FIG. 4. LAWRENCE ST. BRIDGE

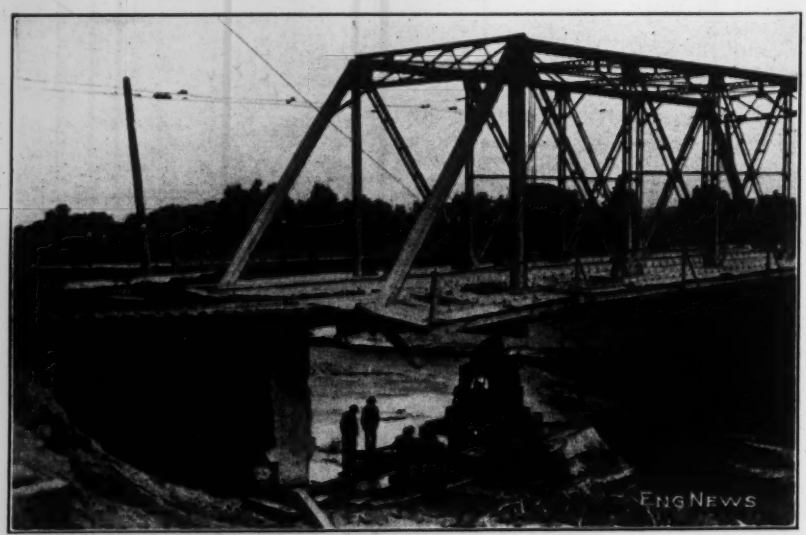


FIG. 5. DOWNING ST. BRIDGE

FIG. 6. CLARKSON ST. BRIDGE

FIGS. 4-6. STEEL BRIDGES THAT WITHSTOOD THE DENVER FLOOD

Subsequently the Mayor conceived the plan of constructing a number of low overfall weirs in the creek bed so as to present to view a series of pools of water instead of a barren sand bed. These weirs were placed with their crests 6 ft. below the top of the wall and so that the crest of each was at the same elevation as the apron of the next one above. Each weir was about 30 in. high. The channel back of each of these weirs promptly filled up with sand, thus defeating the purpose for which they were constructed and substituting a series of steps for the hitherto nearly uniform grade of the creek bed. The area of cross-section was decreased by 25 to 30%, and the mean velocity for a given depth was undoubtedly decreased very appreciably. It is, therefore, safe to say that the carrying capacity of the channel was decreased by from 40 to 50% as a direct result of the construction of the weirs.

There were, however, other causes contributing to limit the possible discharge of the creek, notably the inadequate clearance under some of the older bridges near the river. For instance, the Blake St. approach to the Fourteenth St. viaduct, about one-half mile above the mouth of the creek, had only a few feet clearance at the time of the flood. This structure was built in 1890. At the time of its construction the head room under the girders was much greater than now. After the building of the diversion dam of the Farmers' and Gardeners' Ditch in the South Platte below the mouth of Cherry Creek, both the river bed and the creek bed were slowly raised several feet, the effect being noticeable for two miles above the dam.

Fig. 3 shows the destruction of a brick storm sewer between Lafayette and Downing St., three miles above the mouth of the creek.

The steel bridges, while obstructing the channel, and suffering considerable damage in their lighter parts, all stood under the pressure of the rushing water. Three of these bridges are shown in Figs. 4-6. Fig. 4 shows the Lawrence St. bridge, about a quarter of a mile above Blake St. The girders are eight feet deep.

Fig. 5 shows the damage to the south abutment of the Downing St. bridge. The superstructure was not injured. Fig. 6

shows the damage to the Clarkson St. bridge, about a quarter of a mile below Downing St. The damage here consisted simply in the destruction of the sidewalk on the upstream side. A number of bridges suffered in this way, but none more seriously except that at Downing St., above mentioned, and the York St. bridge, an old pile structure, which was entirely destroyed.

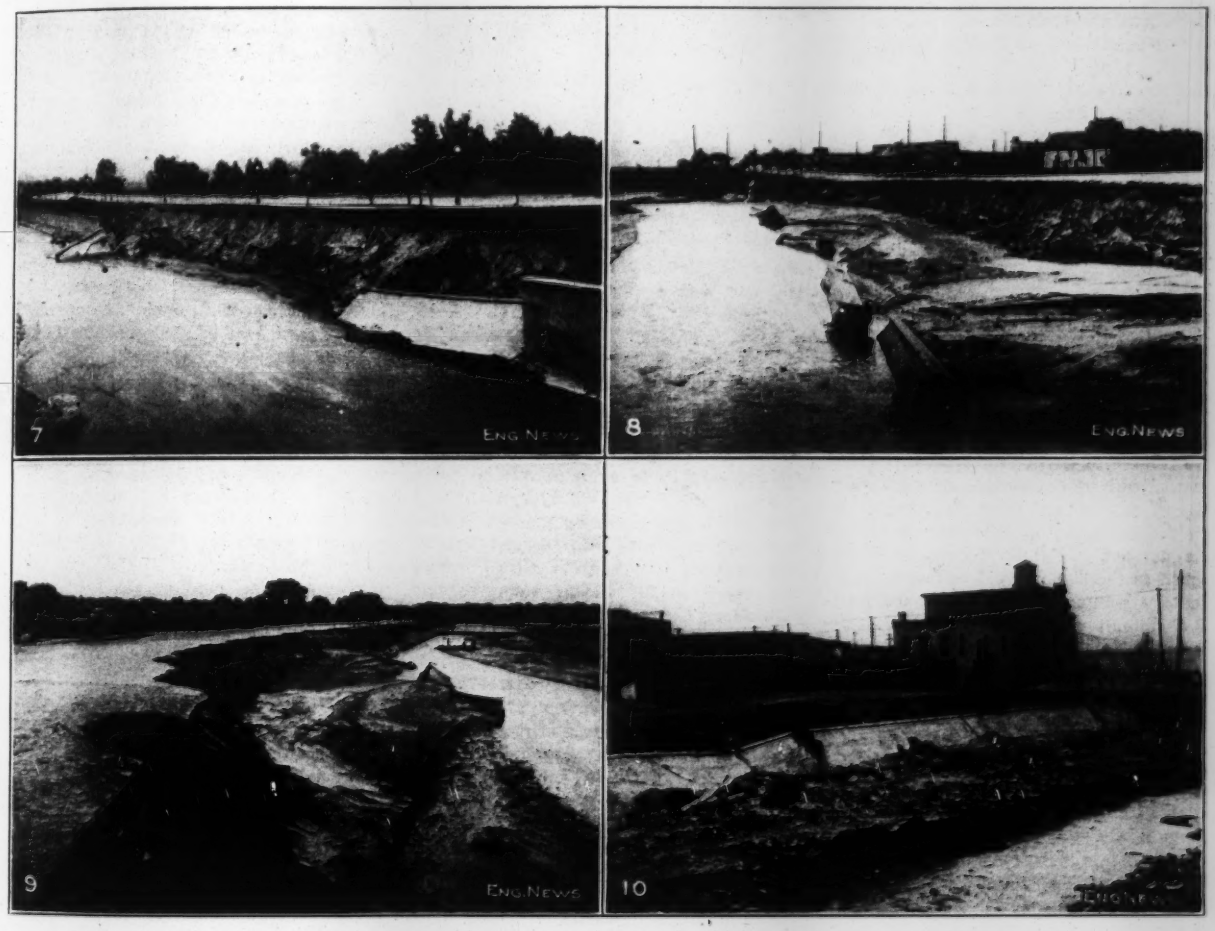
Fig. 7 shows the break in the concrete retaining wall along Speer Boulevard immediately below the Downing St. bridge. the wall was pushed outward. In nearly every other case it fell into the creek.

The city authorities have not yet completed their inventory of damage to city property. It is certain, however, that it is much less than was at first thought. The entire length of wall to be rebuilt will not exceed 1300 ft. out of a total of about six miles. The only extensive damage to the sewers is that shown in Fig. 3. The greatest damage to Speer Boulevard is that shown in Figs. 8-9. Other damage to streets consisted chiefly in the deposits of sand and rubbish which were quickly cleared away.

Twice before in the history of Denver has Cherry Creek had a destructive flood —in 1878 and in 1864. There are few photographs extant of either of these, and absolutely no numerical data by which they may be compared with the flood just past. Such information as we have depends on the memory of "the oldest inhabitant." It seems certain, however, that the property damage was as great on each of these occasions as in the flood of 1912, taking into consideration the total valuation of property then existing.

At intervals during the past thirty years various suggestions for protective measures have been put forward and more or less agitated. The favorite has been the diversion of Cherry Creek through an artificial channel above Denver into Sand Creek, the next tributary to the South Platte River below the city. No one seems to know what such a diversion would cost, but guesses have varied from $600,000 to $2,000,000. The proposed point of diversion is about eleven miles from the mouth of the creek at altitude 5525. It would be necessary to construct eight or nine miles of artificial channel to carry 12,000 cu.ft. per sec. Below the point of diversion there would remain thirty-five square miles of the Cherry Creek drainage area subject to just such torrential storms as occurred on July 14. It would still be necessary to maintain a clear channel through the city and no whit of the expense incident thereto would be abated.

Even if the damage caused by the flood of 1912 be placed at $1,000,000 it is probable that a small part of the cost of the proposed diversion would, considering the infrequency of such occurrences, buy ample insurance to cover all losses.



FIGS. 7-10. DAMAGE TO REINFORCED-CONCRETE RETAINING WALLS, CHERRY CREEK, DENVER

Figs. 8-9 show the damage to the retaining wall and Speer Boulevard just above Broadway bridge, about two miles from the mouth of the creek. This is the longest stretch of damaged wall, the length being about 500 ft. There was a peculiar occurrence immediately below Broadway bridge. Here a large volume of material was removed from behind the wall by the flood, although the wall itself was undisturbed. The wall is founded on piles and it seems probable that the earth was scoured out beneath the concrete. Fig. 10 shows the damaged wall immediately above the Blake St. approach to the viaduct. It is to be noted that at this place

Letters to the Editor

Shipping Cement in Bulk

Sir—While as yet I have no practical experience wherewith to back up my position, I would like to question, on theoretical grounds, one of the points in your editorial on "Shipping Cement in Bulk," in your issue of July 25, 1912, p. 175. You state that cement in bulk may be more liable to injury by exposure to the weather than sacked cement. This is a point on which I cannot agree with you. When cement in cloth sacks is shipped in a leaky box-car the rain that gets through the roof will flow down through the interstices between the sacks until it reaches the car floor, after which it flows over the floor, partially damaging nearly all the sacks with which it comes in contact and thereby probably destroying 10c. worth of sack as well as the 20c. worth of cement contained therein. This not only gives a greater radius of damage, but also subjects the consignee to the trouble of prying the lumps in caked cement out of the sacks; also occasionally of sifting the cement in order to get all the lumps out of it and of resacking the cement. If bulk cement were exposed to the same drip I believe that the damage would be limited to a comparatively small portion of cement immediately under the drip, and all the consignee would have to do would be to lift that lump of caked cement out of his car and throw it away.

Cement is now one of the most inexpensive commodities per ton that we have. Other and more costly materials such as grain, etc., are regularly shipped in bulk without any loss, trouble or expense that is worth considering. Therefore, the price of the commodity is no justification whatsoever for shipping it in packages, while in the case of cement-product factories or construction jobs adjacent to railroad tracks, there is every reason why it should be handled in bulk.

GORDON WILSON, Asst. Secy.,
Universal Portland Cement Co.
Chicago, Ill., Aug. 3, 1912.

Bleeding Steam Receivers to Heat Feed Water

Sir—As G. M. Peek states, in the article in ENGINEERING NEWS, July 18, on "Bleeding Steam from Receivers of Triple Expansion Engines for Heating Feed Water," data on this subject seem to e meager; for this reason, engineers will appreciate his publishing the results of tests.

Yet the scheme is the fundamental basis of the remarkable economies obtained in the record-breaking engines designed by Bruno V. Nordberg. The first noteworthy engine of this type to undergo official test was the Wildwood quadruple-expansion pumping engine of the Pennsylvania Water Co. The test was carried out by Prof. R. C. Carpenter, of Cornell, and very clearly set forth in the scholarly paper, "The Steam Engine at the End of the Nineteenth Century," presented by R. H. Thurston at the December, 1899, meeting of the American Society of Mechanical Engineers.* The last one was a quadruple-expansion air compressor built for the Champion Copper Co., Painesdale, Mich. The result, in the second case named, was a record-breaking duty of 194,300,000 ft.-lb. per million B.t.u. (noted in the paper of Prof. O. P. Hood before the American Society of Mechanical Engineers, December, 1906†). In these engines, and to some extent in others also, the system of stage heating of feed water by bleeding steam from the receivers was worked out by the designer according to a plan which has come to be known since as the "Nordberg Cycle."

While these tests are undoubtedly known to many engineers, nevertheless the remarkable point that comes out is the curious misconception of the true measure of an engine's economy which still prevails amony many men of high attainments. The "duty" of an engine is defined as the "foot-pounds of work accomplished per 100 lb. of coal," or "per 1000 lb. of steam," or "per 1,000,000 B.t.u.," it being assumed that a certain "standard coal" will evaporate 10 lb. of steam giving it approximately 1000 B.t.u. per lb. While it is true that the above is a fair average, nevertheless it is also true that important variations from accuracy may be found under such assumptions. This is strikingly shown in Mr. Peek's data wherein he has found a saving of 9% in favor of the feed-water heating scheme, despite the paradoxical fact of 10,597,000 ft.-lb., or 6.7%, less work being accomplished per 1000 lb. steam. If, on the other hand, the duty were stated in foot-pounds per million B.t.u. supplied to the engine, the paradox would disappear. In other words, the only true measure of economy is the work accomplished for the given amount of heat, or energy properly chargeable to the engine. This last is the heat in the steam entering the throttle less the heat in the feed-water returned to the boiler.

The inability to comprehend this was somewhat amusingly shown in 1906 during the discussion of Prof. Hood's report wherein several commentators endeavored to deprecate the notable performance of the Nordberg engine by comparing the "pounds of steam per indicated horsepower-hour" with the same figures for other engines, which on this basis did fully as well, or even better. It was shown by Prof. Hood that a certain engine, which consumed almost exactly the same steam per indicated horsepower-hour as the Nordberg engine, as a matter of fact used heat in the ratio of 1071 to 852.3 as compared with that used by the latter.

The arrangement suggested by Mr. Day and reported upon by Mr. Peek has one notable difference from that used by Mr. Nordberg. Apparently the heaters are of the closed type and the course of the feed water is continuous from hot-well to boiler, whereas in the Nordberg system the heaters are of the open type with pumps for handling the feed water between. In the Nordberg engine, live steam is abstracted from a receiver, used to jacket the next cylinder, and then passed with its condensation to a feed-water heater. This system makes possible a more uniform temperature drop from throttle to condenser with a consequent gain in economy. It must be confessed that it makes a somewhat complicated layout and requires an engineer of intelligence to operate to the best advantage. From the standpoint of mechanical simplicity, Mr. Day's system possesses several advantages. If, however, the maximum economy possible be the goal sought, it would appear that nothing as yet devised excels the "Nordberg cycle" for reciprocating engines.

The whole subject is an exceedingly interesting one. Mr. Peek's paper gives definite data in regard to savings whose possibilities have long been dimly surmised. If it also makes more vivid the necessity for measuring engine performance on the scientific basis of heat units consumed, it will have enabled many steam engineers to get a better understanding of the directions in which economy may be attained.

L. DOUGLASS ANDERSON,
Assistant Chief Engineer, United States Smelting, Refining & Mining Co., Salt Lake City, Utah, July 31, 1912.

*See Eng. News, Dec. 14, 1899, p. 391.—Ed.

†See Eng. News, Dec. 13, 1906, p. 624.—Ed.

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Engineering News

A long book shelf would be required to hold all the city planning reports that have been made during the past five years, but only a small space would be needed to shelve those which have been officially adopted. Most of the city planning reports have been fathered by voluntary civic organizations and few indeed by city officials. That so many reports have been made and so few adopted should not serve to discourage those enlisted in the city planning campaign. At least a few people in each town and city reported on have become apostles of systematic in place of haphazard city planning, or no planning at all, and in many of the municipalities concerned some portions of the more or less ideal plans now gathering dust will some day become a reality. The necessary educational work attendant upon any great reform has been well started. The hope for the future lies in permanent city planning departments, which shall be integral parts of the city government, vested with carefully devised and gradually increasing powers which will enable them to see that plans once formulated shall be carried out by the city on the one hand and respectfully followed by private interests on the other.

Current climatic and other local conditions which have been observed by that portion of the population which bases its opinions on personal recollections rather than upon trustworthy records are constantly giving rise to the assertion that the climate is changing. Thus in sections of low rainfall, where irrigation has been introduced, we hear it said that increases in the area of land under cultivation are being accompanied with increased rainfall. The facts of the case are that in only a few sections of the United States, if indeed in any, are our meteorological records sufficiently extensive and reliable to comprise even a single complete cycle, with its maximum, minimum and average. Who knows whether fifty to eighty years, which is the span of our longest American rainfall records, embraces a complete cycle? Few of our rainfall records cover as many as forty years, and not many, considering the vast extent and topographical and climatic divergences of our country, extend to near that length of time. Engineers appreciate these facts and uncertainties better than do most classes of people, but even they need to be continually on their guard lest they fail here, as elsewhere, to allow that sort of factor of safety which has been called factor of ignorance but might better be named factor of deficient and unavailable data.

Special faith in some particular material is not unnatural. "There is nothing like leather," used to be said, and today many say, "There is nothing like concrete." It would appear that the New York *Times* held to this latter article of faith, but that its faith has been shaken. The newspaper passed over the various structural accidents of the past year with equanimity, until the latest failure near Gallipolis, Ohio, rouses its alarms. Under a full-face headline, "Another Concrete Dam Falls," it brings together the Austin, (Penn.), dam break and the Gallipolis failure, and leads up to the following forecast: "If a few more big concrete dams break, the critlcisms of concrete are likely to increase." The last phrase, we might add, refers to the alleged prior doubts entertained by "those interested in making walls in the old-fashioned way of stone and brick."

The *Times* editor who wrote the note in question carefully (or ignorantly?) passes over the fact that the Austin dam slid out because its foundation failed, and that this had no more relation to the material composing the superstructure than the color of the *Times* Building has to do with the fall of a coping block from that building. He certainly knows nothing of the details of the Gallipolis failure, since no details have yet been given by the officers in charge. Nevertheless he proceeds to forebode in the matter of concrete, which material is dismally suspected of being not all that "the most uptodate engineers" claim it to be, though a straight-out statement of this suspicion would probably be not "Fit to Print." We dislike to think how much more alarming would have been the editor's comment had he known of other recent accidents involving concrete; for example, the washing out of a concrete retaining-wall along Cherry Creek in the high-water at Denver a few weeks ago.

Unfortunately, the engineer is bound to look on such lay utterances as an indication of what the general public thinks on the subjects in question. If a general suspicion, however unreasoning, should arise concerning the stability of concrete structures, the engineer's path will be made rougher than necessary. This is the only consideration that makes the *Times* suspicionings of interest.

The British and the American "Titanic" Investigations

We give in another portion of this issue an abstract of the final report of the British official commission appointed to investigate the loss of the steamship "Titanic," and append thereto the recommendations of the U. S. Senatorial Committee, which reported on the same subject some two months ago. Strangely enough, and contrary to the general expectation, the two reports are essentially the same in effect, though differences in national temperament lent a somewhat different hue to the conduct of the two inquiries and to the manner of expressing the opinions of those who had them in charge.

The American investigation was in charge of politicians, though statesmen may possibly be the more respectful term. For the most part, the investigators were lawyers, and outwardly at least they did not deign to call into consultation any expert on marine matters. The inquiry was started when the horror of the diaster was fresh in the minds of everyone and assumed at times more of the character of the much-despised coroner's inquest than a dignified, sober investigation. Ignorant questions and spectacular oratory played a very important part in the investigation proper and the public soon came to discredit the committee and its possible findings even before these findings were brought in.

The British Commission, in contrast, was made up of a Commissioner who had long experience in maritime affairs and five assistants who were either members of the navy, the naval reserves or experts on naval design. The inquiry was held after the first wave of horror of the accident had passed and was conducted under the most dignified conditions. In addition to the expert character of the court itself, a great effort was made to bring before it a number of engineers and seamen who were expert in the design and operation of ocean-going vessels.

Finally the one great moral difference in the two commissions lay in the fact that the greater percentage of those lost were Americans, while the laws and individuals responsible for the catastrophe were for the most part British. Though none of the gentlemen concerned would probably admit it, the one was an avenging body; the other a vindicating.

In spite of these great differences in make-up, procedure and intent, the final recommendations of the two commissions —and we wish to emphasize the word "recommendations"—were about the same. Place them side by side. Senator Smith's commission recommends lifeboats for the whole complement of the ship, frequent life-boat drills, a wireless man always on duty, a double skin for the hull, longitudinal bulkheads and watertight decks. So does Lord Mersey's court. With the difference that the American commission, ignorant of all things marine but cocksure in its judgment, recommends that these provisions be incorporated in law; the British court, while possessing no little technical ability, refuses to accept final responsibility for its opinions, but urges their study upon the properly qualified Board of Trade before final legal measures are adopted. In only one minor detail is there a difference; the American committee recommends the compulsory use of searchlights, presumably to detect icebergs; the British court, on testimony of experts, rejects them as of no value for that service. On the other hand, the English court emphasizes the lack of sufficient lookouts on the "Titanic," which is not made a point of comment in the American report.

So much for the technical features of the reports. As regards the construction of the ship, and the circumstances of the accident, the two reports agree as to details, though the British report is the more concise of the two in this regard. Finally, in the matter of assigning responsibility for the disaster, there is a marked dissimilarity. The American commission, after an investigation conducted somewhat on the principle of the French courts, that everyone is guilty until proved innocent, avoided all reference to the question of responsibility in its report, and contented itself with a brief reference to the negligence of the captain of the "Californian" and severe condemnation of the wireless transmission of news *subsequent* to the sinking of the vessel. The British court, taking care of its own, spread an enveloping coat of whitewash over all the persons concerned in the loss of the ship (except the unfortunate master of the "Californian"), and rebuked the Board of Trade somewhat mildly for its true British conservation in not revising its rules in 18 years, and transatlantic seamen in general for certain time-worn customs that would seem to be the better for reform. In fact, the result of the reams of testimony on both sides of the ocean simmers down to the ancient verdict, "Nobody's to blame, but don't do it again."

It may be remarked that the final report of the U. S. Senate Committee is much more moderate than the utterances of its chairman, Senator Smith, either during the hearings or in the speech printed as an appendix to the original report. It is fair to assume that this moderation is due to the other members of the Committee.

It now remains to be seen to what degree the concurrent judgment of a body of American lawyers and a body of English marine experts, based in each case on comparatively brief investigations of one marine disaster, will be confirmed by the technical experts of the British Board of Trade in application to the vast number of vessels sailing under the British flag.

Curve Resistance and Grade Compensation for Curves

The factor of train resistance which is represented by the resistance incident to curves is mainly of an indefinite character, so far as our present knowledge goes, since the value assigned to it is based usually on antiquated experiments which (while remarkably thorough for their time) can hardly be accepted as applying under present-day conditions of railway equipment and operation. But it is most desirable that a real basis should be determined, since curve resistance is a highly important consideration in railway location and improvement and in the determination of weight of maximum trains. And this tonnage rating of trains is one of the important features of modern developments in the economy of railway operation.

A factor in railway location and relocation which is given a very variable degree of attention and importance is the compensation of grades for curvature; in other words, the reduction of grades below the nominal grade (for straight line) wherever curves are introduced. This reduction is made to offset the additional train resistance due to the curve, and theoretically it should be such that the combined or total train resistance on the combined grade and curve will be equal to the train resistance on the normal grade on tangent or straight line.

The physical result of this compensation is a loss in elevation at the end of each curve, the elevation being below that of the normal grade line on the profile. This loss is, of course, cumulative, and may reach a serious amount on a long ascent having numerous curves. This will be most serious for lines in difficult or mountain country, where the location may fix certain definite summit elevations; but it is on just such lines that the loss will be greatest, since they are the lines that are likely to involve long and heavy grades and numerous curves. To avoid such loss of elevation under these conditions, the grades on straight portions of the line must be increased or the developed distance must be increased.

It is evident that the problem of grade compensation for curvature is a difficult one, involving important elements which affect location, construction, cost and operation. It has been discussed by different writers, and many varying views are held regarding the subject in general and the rate of compensation in particular. The subject was discussed by us in 1908*, but it will be of interest at this time to review both the problem and principles upon which it is based, es-

*Engineering News, Apr. 16 and June 11, 1908.

pecially in relation to modern railway conditions. Elsewhere in this issue we present a summary of the statements of some writers upon the subject.

The basis of the amount of compensation to be given is the amount of curve resistance, and it must be admitted that our knowledge on this point is somewhat indefinite and refers to early rather than to present conditions of trains and railway operation. This matter we have referred to later. In his classic work on "The Economic Theory of the Location of Railways" (1887), Mr. Wellington stated that until within recent years nearly all American railways had been constructed without compensation; and when it was used, the rates were usually low (0.02 and 0.03%). For these rates, he stated, much could be said, although in general a less rate than 0.05% could not be regarded as good practice, and he considered 0.03% as the minimum rate. He advocated the extensive use of compensation for curvature, stating that unreduced grades on curves should not be permitted on the maximum grade under any circumstances and that the reduction in general should be ample. It would appear, however, that this teaching has been carried rather to an extreme, more particularly as to the recommendation of an "ample" rate of compensation, and at the present time the tendency is toward the lower rather than the higher rates of compensation.

The practice of reducing grades on curves appears to have been introduced first on the Continent, and American engineers soon followed, although many prominent roads neglected it entirely. The argument for this neglect was that the resistance is averaged by momentum, but Wellington showed that this did not apply under the conditions of railway operation, and as a matter of fact trains moving at the slow speed of maximum trains on maximum grades would be liable to be stalled on curves. And a stoppage of the train on a long uncompensated curve would be a "disastrous disadvantage," especially if on a long succession of curves which prevents backing down off the curve to get a good start for running it at higher speed. Then the grade at that point becomes the limiting grade, and cannot be overcome by striking an average with lower tangent grades above and below.

The problem is further complicated by the conditions of the location of individual curves. Thus, on curves at or immediately above stopping places the rate of compensation must be higher than that normally used, in order to avoid the liability of trains being unable to start or being quickly stalled due to the higher resistance at low speed. In some cases, also, specially high compensation is given in tunnels, to allow for loss of adhesion due to wet or slippery rails.

For curves on the open line, where trains run at normal speed, the rates of compensation have ranged from zero to 0.06% (or even 0.08%) per degree of curve. Present practice, however, tends toward a medium rate between 0.03 and 0.04%, several roads reporting the former as too low and the latter as too high. The various statements given elsewhere we may summarize as follows, showing the compensation per degree of curve:

Wellington (1887)	0.05%
Haynes (1903)	0.03% for 1° to 0.02% for 20°
Lavis (1906)	0.06% up to 2.° to 0.03% for 8°
Tratman (1908)	generally 0.03 to 0.04%
Raymond (1909)	0.04% for 1°, to 0.025% for 5°
Webb (1909)	ordinarily 0.05%

An interesting example of the variations in modern practice is afforded by a comparison of the location and compensation on two rival and parallel lines built at the same time (and only a few years ago) in difficult mountain country. These lines are the Oregon Trunk Ry. (Hill System) and the Des Chutes Ry. (Harriman System), built up the Des Chutes River valley from the Columbia River to the interior of Oregon. The former secures a location within limits of 1.3% grades and 6° curves; its compensation is at the rate of 0.04% per degree, regardless of whether the curve is light or heavy; under these conditions, full-tonnage trains on long stretches of maximum grade are found to accelerate slightly on curves, indicating that 0.04% is ample compensation. The latter railway has a less favorable location, having limits of 1.5% for grades and 12½° for curves; the compensation for maximum grades is 0.035% up to 6°, 0.045% up to 8½° and 0.050% up to 10°. In this latter case, the rate of compensation increases with the degree of curve, although the reverse practice is now the more general and appears to have the weight of argument in its favor.

In regard to grade compensation under special conditions, the Oregon Trunk Ry. in locating on maximum grades allows 0.14% compensation through passing tracks and for 1000 ft. beyond each end; as the sidings are 3000 ft. long, this amounts to 7 ft. vertical loss in elevation. This is done in order to avoid damage to drawbars in starting full-tonnage trains, and also to reduce the time lost in heading into and pulling out of sidings. A further compensation of 0.25% is made at tunnels over 100 ft. long located on maximum grade; this is in order to avoid trains stalling on bad or slippery rails in the tunnel, and also to minimize drawbar troubles with full-tonnage trains. The Des Chutes Ry. makes no compensation in tunnels.

The discussion of or controversy over the subject is by no means new. In our issue of Feb. 11, 1882, a letter from H. A. McClellan was quoted (from the *Railroad Gazette*) stating his practice in 1881 on the Nevada & Oregon Ry. (3-ft. gage). The grades were limited to 100 ft. per mile and curves to 18°. On the first five miles the reduction was 0.1% per degree but this was believed to be too much for light curves and too little for sharp curves. A variable compensation was then adopted, ranging from 0.02% for 1° to 0.06% for 8°, and 18° curves were laid level. The reduction in maximum grade on curves below that on tangent was 0.03% for 2° to 2.01% for 20° curves. Of course, the corresponding rate for standard-gage lines would be somewhat less, as noted below in regard to some tests on Australian railways. In our issue of Mar. 8, 1884, Mr. Whittekin gave a table of compensation deduced from some experiments made in Pennsylvania. His compensation per degree ranged from 0.038% for 1° to 0.191% for 5°, 0.399% for 10°, and 0.676% for 15°, which again is an example of increasing the rate with the increase in degree of curve.

Another early treatment of this subject, but dealing with it from the standpoint of experience rather than investigation, was in a paper by W. R. Morley read before the American Society of Civil Engineers in 1884. On the Veta Pass line (3-ft. gage and 4% maximum grade) in 1867, no compensation was used on curves of less than 10°; it began with 0.05% for 11° and increased until at 30° the line was level. This was found to be too much, especially in the higher curves. As a result, on different lines of the Atchison, Topeka & Santa Fe Ry., having maximum grades of 0.6% to 3.5%, the compensation adopted was 0.05% per degree for all curves up to the 10° maximum. This was found to be about right for 0.6% grades, but on grades of 1.2% the loaded trains showed a marked increase in speed; and this increased with the increase in sharpness of curve. A rule was then adopted for varying the compensation according to the maximum grade, as follows: 0.06% for grades up to 0.7%; 0.05% for grades up to 1.4%, and 0.04% for grades up to 2%. Later this was modified by giving the compensation noted for grade limits of 0.7%, 1.6% and 3% respectively. With this compensation trains did not accelerate speed on the curves. In some cases they were found to drag, but this proved to be due to imperfections in track (such as failure to widen the gage on curves). Practice on Eastern railways at that time was to vary the compensation with the degree of curve and to use a different rate of compensation on different maximum grades.

In the discussion on this paper the late A. M. Wellington stated that no fixed rate of compensation, to be used invariably, can or should be adopted. If there is no great difficulty in introducing compensation, it is proper to adopt a liberal rate. But when (as in difficult country) every decrease on curves means a corresponding increase on tangents it

is inexpedient to adopt a higher rate of compensation than is certainly necessary to prevent excessive resistance on curves. He thought a rate of 0.1% per degree higher than is ever necessary, except in certain cases at stations. On the Mexican Central Ry. he used 0.04%; doubling this near stations and stopping points.

It appears evident that in many cases, and particularly in earlier years, an excessive amount of compensation has been allowed, as indicated by the observed fact of trains tending to accelerate speed on curves due to the train resistance being actually below the normal. The early practice was to increase the rate of compensation with the increase in degree of curve, but this is now recognized generally as erroneous, and (following Wellington's expression on this point*) modern writers and engineers commonly advocate a reduction of the rate of compensation as the sharpness of curve increases. This is due to the fact that curve resistance and total resistance do not increase proportionately with the increase in degree of curve. Another source of trouble has been a tendency to adopt some one particular rate and to use this under all conditions, while as a rule the rate may and should be varied according to conditions of location and operation. Ten years ago (in our issue of June 19, 1902) we gave voice to the suggestion that compensation for curves was being overdone. In a description of the system employed on the South Australian Government Railways† we made the following statement:

"The main object in compensating maximum grades for curvature is to avoid the stalling of heavy freight trains in climbing such a grade. It has become so much the custom in recent years to compensate grades for curvature that very possibly some needless work of this sort has at times been done. The best exposition on the subject that we know of is in the late A. M. Wellington's 'Economic Theory of Railway Location.' The summary of its ten practical conclusions may prove a serviceable guide to some of the younger generation of engineers who are following the custom of compensating grade for curvature according to some hard and fast rule."

So much for the general proposition and its application. Now let us consider for a moment upon what basis is present practice determined, the real basis of the problem being the train resistance directly due to curvature. It must be admitted that in most cases the statements made in engineering books as to this subject are based largely upon opinion and practice and upon the statements of previous writers. And in most cases also, the compensation adopted on different railways is based upon opinion and previous practice, supplemented perhaps by more or less careful observation of the behavior of trains. From this it is evident that grade compensation for curvature as now practiced is largely a matter of "rule-of-thumb."

The real basis, as noted above, is curve resistance. But it remains to be determined what this resistance actually amounts to, or how it varies with different conditions of track and equipment in modern railway service. Most theoretical considerations of the matter are based upon the car-resistance experiments made by Wellington in 1878 on the L. S. & M. S. Ry.; these consisted of dropping cars from rest down a known grade and deducing the resistance from the velocity acquired. We know of few extensive or thorough tests representing modern conditions. Searles (1887) said: "Experiments for determining the amount of resistance have been neither numerous nor very satisfactory, but the generally accepted conclusion is that the resistance is a little less than ½ lb. per ton for a 1° curve, and that it varies as the degree of curve." This figure is often used, but Wellington had previously shown that the resistance does not vary directly with the degree of curve:

"The lowest probable limit of curve resistance at ordinary freight speeds and ordinary curves is about ⅓ lb. per degree of curve, with all in perfect order. With worn rails and somewhat rough track, it may be as high as ⅔ lb. Curve resistance per degree is much greater on easy curves than on sharp curves, so that when the resistance is (for example) 1 lb. per ton on a 1° curve it may be 6 to 8 lb. on a 10° and not more than 15 to 18 lb. on a 40 to 50° curve."

"Curve resistance varies from less than 0.5 lb. to probably 2 lb. per ton (or even more) per degree of curve, according to circumstances. With a grade resistance of 2 lb. per ton for each tenth of grade,* this is equivalent to 0.025% to 0.10% of grade per degree of curve. Assuming an uncompensated grade of 0.5% with alternate equal length of tangent and 10° curves, and assuming the curve resistance is at the rate of 1 lb. per ton, the effect of the curve resistance is in effect to double the grade on curves."

Curve resistance consists mainly of the following factors: (1) friction due to longitudinal and lateral movement of the wheel on the rail head, (2) friction due to the wheel flange bearing against the rail head, (3) friction in the center plates, which checks the free swinging of the truck. There are numerous indeterminate factors affecting actual results; these include the condition of maintenance of cars, the condition of the rails, and the condition of the track as to surface, gage and true curvature. Track having rough surface, bad (that is, irregular) alignment of curves, improper widening of gage or superelevation of rails on curves, and rails with worn rail heads will tend to increase the resistance materially. The resistance decreases also with decrease in train speed. Wellington states that on a 1° curve it is over 1 lb. per ton at 12 m.p.h. and about ½ lb. at 22 m.p.h.; while on an 8° curve, it is 8 lb. at 8 m.p.h. and 5½ lb. at 19 m.p.h. Curve resistance has been discussed and analyzed theoretically, but very few practical investigations have been made on a sufficient scale to form any exact check upon the generally accepted (or disputed) conditions. The most extensive and thorough tests were those made by Wellington on the Lake Shore & Michigan Southern Ry. in 1878, and these form the basis of most modern discussions on curve resistance. It is doubtful, however, if the results apply directly or without modification under modern conditions of car construction, track and train service.

We are aware that some tests have been made in recent years,* but none of these, so far as we are aware, have been of sufficient importance to establish definite conclusions of universal application. Tests made on the Pittsburgh & Lake Erie Ry. in 1904 showed that the effect of ball bearings under the center plates and side plates of cars had a marked influence upon the curve resistance, and consequently upon the rate of grade compensating. This is interesting (although the result is what might be expected), but it has little bearing upon the problem, since the proportion of cars fitted with such anti-friction devices to allow free movement of the trucks is so small that it can have no influence upon average trains and average conditions. Nevertheless, it is probable that greater care in the equipment and maintenance of cars with a view to their easy running condition would prove a practical and important economy in operation. And it has been shown above that track maintenance is an important factor affecting resistance.

In conclusion, we wish to express the opinion that it is highly desirable to have some thorough and comprehensive tests made as to curve resistance under modern conditions of rolling stock and traffic. There should be no great difficulty in arranging this, through the co-operation of railways and engineering

*See his ninth conclusion, quoted elsewhere.

†In this system, which was applied to lines of 3½-ft. gage, the rule for compensation was that the rise (in feet per 66-ft. chain) on a curve whose radius is R (number of chains) should be the rise upon a tangent minus 2 ÷ R. For standard gage this would be 2.69 ÷ R.

*Grade resistance equals rate of grade per cent. × 2. That is, on a 1% grade the grade resistance is 20 lb. per ton; on a grade of 0.4% it is 8 lb. per ton.

*Including tests on the Baltimore & Ohio Ry., 1909, as noted in the article in another column. Records of these tests are given in the Proceedings of the American Railway Engineering Association, 1910.

societies, using dynamometer cars owned by railways or engineering colleges. Only a limited number of skilled observers would be required, and there would be little interference with traffic. The work might be done preferably on mountain lines, where long grades and numerous curves occur, and the tests should be made preferably under the normal condition of the train ascending the grade rather than by dropping the train or car down the grade through the curves. The tests should include observations as to the influence of condition of track and rolling stock.

As to the desirability of such curve resistance tests we quote from a letter received recently:

> All railways that I know of over-compensate for curves because "it is Searles" and orthodox. There are no intelligible experiments since Wellington, 30 years ago; but it is so easy to make them. Is it not possible for one of the engineering societies to appropriate $2000 or $3000 to that work? Then when they see the results they would keep it up. All the roads would want their resistances determined and would contribute toward the expense.
>
> Watches, pencils and note books are the only instruments needed. The regular operation of the roads would not be interfered with materially. The work would be best done in the mountain districts of transcontinental lines. Where solid trains run hundreds of miles with no local work, cars uniform and road-bed good, then all that is necessary is to keep the engine pull uniform and measure the speed accurately. Variation of speed taken with the profile and alignment will tell the whole story. Probably the best results would be obtained in coasting down-hill, although the compensation is for trains running in the opposite direction. The instruments found in the dynamometer car are not accurate enough. I think speed would have to be determined by counting wheel revolutions. Speed is all important and I do not think a recorder can be made to fill the bill. One man on the engine would be needed with ample authority; also two others in the caboose to note speed, mile posts, wind, weather, condition of rail and wheels, etc. The train must be handled also by an experienced engineman.
>
> Of course, experiments should be made with all kinds of trains and judgment should be used in selecting parts of the road which will give results in a simple form. The results for a long train covering many complex curves might not be worth much. Probably some of the best results would be with a pusher engine dropping down its grade. The engineer should be experienced in maintenance of way, know how to manage trainmen and make reasonable requests. He ought to be able to determine a proper rule for curve compensation in grades. He may find an error in the immortal Wellington's method of getting this rule by dropping cars down a grade, when the actual condition is pulling them up.
>
> We know that trains lose speed and stall on tangents and pick up on the curves compensated by the "Harriman" and other standards. That is, the low-grade employees know it; the men who are there and see it in the wet, cold and dust at all hours of the day and night. It is not discernable on passenger trains. It is never reported. But if the speed curve, profile and alignment could be plotted together, so that it could be studied in the office, resistance would be smoothed out and overcome, and money would be saved in railway operation.

The question of curve resistance is of such importance as affecting location and traffic and ultimately the economy of railway operation, that it seems to us some steps should be taken without delay to make definite determinations of the character noted above.

The British Official Report on the "Titanic" Disaster

The report of the special Court of Inquiry appointed by the British Government to investigate the loss of the White Star liner "Titanic," was made public on July 30. This report is signed by the Wreck Commissioner, Lord Mersey, and is concurred in by five other members of the Court, Rear-Admiral F. A. Calthorp, of the British Navy; Commander F. C. A. Lyon and E. C. Chaston, of the Royal Naval Reserves; Prof. J. H. Biles, Professor of Naval Architecture at the University of Glasgow, and Capt. A. W. Clarke. The report comprises 74 pages of printed matter and contains only the findings of the commission and none of the testimony.

The main finding of the Court is as follows:

> The court, having carefully inquired into the circumstances of the above mentioned shipping casualty, finds that the loss of the said ship was due to collision with an iceberg brought about by the excessive speed at which the ship was being navigated.

The report, however, qualifies this last statement by a condemnation of the practice of continuing along a course known to be icebound, which practice was followed by Captain Smith, of the "Titanic." The Court holds that Captain Smith was not to blame for this, but that the fault lay in the invariable practice which should be remedied in the future. No reflection is cast on the officers or the crew of the ship or on any of the officers of the company, which, according to the Court, fulfilled all the requirements of the law for the safety of its vessel. The only specific accusation of negligence is that insufficient look-outs were provided to protect the vessel against possible icebergs.

The report finds that the discipline of the ship was good, but that the lack of complete organization during the lowering of the boats tended to reduce the number of those saved. The life-boats left without full loads in nearly every case, largely because most of the passengers considered the ship safer than the life-boats and partly because the knowledge of the coming of the "Carpathia" was fairly wide among those on the decks. Furthermore, many probably saw the lights of the "Californian." The captain of this latter vessel is severely condemned for his negligence in not coming to the aid of the "Titanic," which, according to the testimony, could not have been farther distant than 10 miles and was possibly but five miles away. The charges against Mr. Ismay, the president of the line, and against certain members of the British nobility who were passengers of the ship, involving questions of personal responsibility, were considered by the Court to be unfounded.

The report further recommends that the recently appointed Bulkhead Committee of the Board of Trade should inquire into the desirability and practicability of providing ships with additional bulkheads, a double-skin and watertight deck. While making some general recommendations regarding the structure and equipment of ships and criticizing the Board of Trade for not having revised its rules and regulations since 1894, the Court seems reluctant to consider itself sufficiently expert to formulate such rules which, in its opinion, should be taken up by the authorities of the Board of Trade, the official British body for the regulation of the construction and operation of ocean-going vessels.

Recommendations

The specific recommendations of the Court are as follows:

Watertight Subdivision.

The following recommendations refer to foreign-going passenger and emigrant steamships(

1. That the newly appointed Bulkhead Committee should inquire and report, among other matters, on the desirability and practicability of providing ships with (a) a double skin carried up above the waterline: or, as an alternative, with (b) a longitudinal, vertical, watertight bulkhead on each side of the ship, extending as far forward and aft as convenient: or (c) with a combination of (a) and (b). Any one of the three (a) (b) and (c) to be in addition to watertight transverse bulkheads.

2. That the Committee should also inquire and report as to the desirability and practicability of fitting ships with (a) a deck or decks at a convenient distance or distances above the waterline which shall be watertight throughout a part or the whole of the ship's length; and should in this connection report upon (b) the means by which the necessary openings in such deck or decks should be made watertight, whether by watertight doors or watertight trunks or by any other and what means.

3. That the Committee should consider and report generally on the practicability of increasing the protection given by subdivision; the object being to secure that the ship shall remain afloat with the greatest practicable proportion of her length in free communication with the sea.

4. That when the Committee has reported upon the matters before mentioned, the Board of Trade should take the report into their consideration and to the extent to which they approve of it should seek statutory powers to enforce it in all newly built ships, but with a discretion to relax the requirements in specia cases where it may seem right to them to do so.

5. That the Board of Trade should be empowered by the Legislature to require the production of the designs and specifications of all ships in their early stages of construction and to direct such amendments of the same as may be thought necessary and practicable for the safety of life at sea in ships. (This should apply to all passenger carrying ships.)

Lifeboats and rafts.

6. That the provision of life boat and

raft accommodation on board such ships should be based on the number of persons intended to be carried in the ship and not upon tonnage.

7. That the question of such accomodation should be treated independently of the question of the subdivision of the ship into watertight compartments.

8. That the accommodation should be sufficient for all persons on board, with, however, the qualification that in special cases where, in the opinion of the Board of Trade, such provision is impracticable, the requirements may be modified as the Board may think right. (In order to give effect to this recommendation changes may be necessary in the sizes and types of boats to be carried and in the method of stowing and floating them. It may also be necessary to set apart one or more of the boat decks exclusively for carrying boats and drilling the crew, and to consider the distribution of decks in relation to the passengers' quarters. These, however, are matters of detail to be settled with reference to the particular circumstance affecting the ship.)

9. That all boats should be fitted with a protective, continuous fender, to lessen the risk of damage when being lowered in a seaway.

10. That the Board of Trade should be empowered to direct that one or more of the boats be fitted with some form of mechanical propulsion.

11. That there should be a Board of Trade regulation requiring all boat equipment to be in the boats as soon as the ship leaves harbor. The sections quoted above should be amended so as to provide also that all boats and rafts should carry lamps and pyrotechnic lights for purposes of signalling. All boats should be provided with compasses and provisions, and should be very distinctly marked in such a way as to indicate plainly the number of adult persons each boat can carry when being lowered.

12. That the Board of Trade inspection of boats and life-saving appliances should be of a more searching character than hitherto.

Manning the Boats and Boat Drills.

13. That in cases where the deck hands are not sufficient to man the boats enough other members of the crew should be men trained in boat work to make up the deficiency. These men should be required to pass a test in boat work.

14. That, in view of the necessity of having on board men trained in boat work steps should be taken to encourage the training of boys for the Merchant Service.

15. That the operation of the Merchant Shipping Act, 1894, should be examined, with a view to amending the same so as to secure greater continuity of service than hitherto.

16. That the men who are to man the boats should have more frequent drills than hitherto. That in all ships a boat drill, a fire-drill, and a watertight door drill should be held as soon as possible after leaving the original port of departure and at convenient intervals of not less than once a week during the voyage. Such drills to be recorded in the official log.

17. That the Board of Trade should be satisfied in each case before the ship leaves port that a scheme has been devised and communicated to each officer of the ship for securing an efficient working of the boats.

General.

18. That every man taking a look-out in such ships should undergo a sight test at reasonable intervals.

19. That in all such ships a police system should be organized so as to secure obedience to orders, and proper control and guidance of all on board in times of emergency.

20. That in all such ships there should be an installation of wireless telegraphy, and that such installation should be worked with a sufficient numberof trained operators to secure a continuous service by night and day. In this connection regard should be had to the resolutions of the International Conference on Wireless Telegraphy recently held. That where practicable a silent chamber for "receiving" messages should form part of the installation.

21. That instruction should be given in all Steamship Companies' Regulations that when ice is reported in or near the track the ship should proceed in the dark hours at a moderate speed or alter her course so as to go well clear of the danger zone.

22. That the attention of Masters of vessels should be drawn by the Board of Trade to the effect that under the Maritime Conventions Act, 1911, it is a misdemeanor not to go to the relief of a vessel in distress when possible to do so.

23. That the same protection as to the safety of life in the event of casualty which is afforded to emigrant ships by means of supervision and inspection should be extended to all foreign-going passenger ships.

24. That (unless already done) steps should be taken to call an International Conference to consider and as far as possible to agree upon a common line of conduct in respect of (a) the subdivision of ships; (b) the provision and working of life-saving appliances; (c) the installation of wireless telegraphy and the method of working the same; (d) the reduction of speed or the alteration of course in the vicinity of ice; and (e) the use of searchlights.

The U. S. Senate Committee's Report on the "Titanic"

In connection with the above report, we append below the final "recommendations" of the investigating committee of the U. S. Senate, headed by Sen. W. A. Smith, of Michigan, which was presented on May 28, 1912.

On another page we have commented editorially on the two reports.

The committee finds that this accident clearly indicates the necessity of additional legislation to secure safety of life at sea.

By statute the United States accepts reciprocally the inspection certificates of foreign countries having inspection laws approximately those of the United States. Unless there is early revision of inspection laws of foreign countries along the lines laid down hereinafter, the committee deems it proper that such reciprocal arrangements be terminated, and that no vessel shall be licensed to carry passengers from ports of the United States until all regulations and requirements of the laws of the United States have been fully complied with.

The committee recommends that sections 4481 and 4488, Revised Statutes, be so amended as to definitely require sufficient lifeboats to accommodate every passenger and every member of the crew.

Not less than four members of the crew skilled in handling boats should be assignod to every boat. All members of the crew assigned to lifeboats should be drilled in lowering and rowing the boats, not less than twice each month and the fact of such drill or practice should be noted in the log.

The committee recommends the assignment of passengers and crew to lifeboats before sailing; that occupants of certain groups of staterooms and the stewards of such groups of rooms be assigned to certain boats most conveniently located with reference to the rooms in question; the assignment of boats and the shortest route from stateroom to boat to be posted in every stateroom.

The committee recommends that every ocean steamship carrying 100 or more passengers be required to carry two electric searchlights.

The committee finds that this catastrophe makes glaringly apparent the necessity for regulation of radiotelegraphy. There must be an operator on duty at all times, day and night, to insure the immediate receipt of all distress, warning or other important calls. Direct communication either by clear-speaking telephone, voice tube, or messenger must be provided between the wireless room and the bridge, so that the operator does not have to leave his station. There must be definite legislation to prevent interference by amateurs, and to secure secrecy of radiograms or wireless messages. There must be some source of auxiliary power, either storage battery or oil engine, to insure the operation of the wireless installation until the wireless room is submerged.

The committee recommends that the firing of rockets or candles on the high seas for any other purpose than as a signal of distress be made a misdemeanor.

The committee recommends that the following additional structural requirements be required as regards ocean-going passenger steamers, the construction of which is begun after this date:

All steel ocean and coastwise seagoing ships carrying 100 or more passengers should have a watertight skin inboard of the outside plating, extending not less than 10% of the load draft above the full-load waterline, either in the form of an inner bottom or of longitudinal water-tight bulkheads, and this construction should extend from the forward collision bulkhead over not less than two-thirds of the length of the ship.

A Bad Fire occurred at Pier No. 72, 33d St. and North River, New York City, on Aug. 10, destroying it and doing damage to Pier No. 73. Both of these piers are the property of the New York Central, and the fire was started by sparks from the stack of a Central freight locomotive running along Eleventh Ave.

Excessive Speed is given as the cause for the wreck on the Chicago, Burlington & Quincy R.R., at Western Springs, Ill., July 14. The Illinois Railroad & Warehouse Commissioners, on investigation of this accident, advocate the use of the automatic block signal system. Their report places the blame for the accident in three places, the public demand for through trains at dangerously high speed, the Government demand for fast mails, and the railroad company's custom of running high-speed trains too close together.

A Head-on Collision occurred on Aug. 5, between a four-coach passenger train and a heavily loaded freight train on the single-track line of the Baltimore & Ohio R.R., near Washington, Penn. Two people were killed and nine injured by this accident, which occurred near the scene of a similar accident two years ago. There is a curve in the track at this point and the engineers of the two trains were unable to apply the brakes quickly enough to avoid the collision. The blame for the wreck is placed on the crew of the freight train, as the passenger train had the right of way at the time of the accident.

A Railway Wreck on the Plymouth Division of the New York, New Haven & Hartford R.R., at Dorchester, Mass., caused the death of five and the injury of 52 persons among the passengers and train crew. The train was traveling at about thirty-five miles an hour when the engine jumped the track at a curve, dragging its tender and the first three coaches after it. Most of the injured were in the first and second coaches, which were ripped open and overturned in passing by the disabled locomotive and tender. The exact cause of the accident is not known, but an investigation is being made by the railroad officials to find out where the fault lies.

The Second Accident within a week occurred, on Aug. 2, on the line of the Central Brazilian Ry., at Rio de Janiero, Brazil. Two hundred persons were reported as killed or injured.

An Explosion of Firedamp and coal dust occurred, on Aug. 8, in the Lorraine shaft at Gerthe, Germany, and resulted in the death of 103 miners and in the injury of 25 others. The accident took place when the day shift was starting work, and it is attributed to the ignition of a pocket of gas which was reached by the flame from a blast.

A Dynamite Explosion at Shaft 12, of the high-pressure tunnels of the Catskill water-supply system, 106th St. and Central Park West, New York City, on Aug. 9, killed five laborers and injured six others. These men were drilling, preliminary to setting off a blast and were working about 300 ft. underground when one of the drills struck an old unexploded charge of dynamite.

A Water Tank on the roof of the Union American Cigar Co.'s factory at Pittsburgh, Penn., collapsed on Aug. 7, killing three girl workers, and injuring twelve others. The building and tank were newly erected. The failure is attributed, either to the buckling of a girder, or to weakness in one of the sustaining walls. Débris from this wall wrecked the fire escapes.

The Hudson Tunnel System in New York City, which was to be extended from its present terminus at Sixth Ave. and 33d St. by way of Sixth Ave. northerly to 42d St. and Fourth Ave., has secured an extension of time to Apr. 28, 1914, for beginning work on this prolongation. The prolongation was designed to make direct connection with the Grand Central Terminal Station of the New York Central & Hudson River R.R.

The Moving Platform Project in New York City, on which the Public Service Commission some time ago took favorable action by laying out a route (which is the first preliminary to construction), has been set back by the Commission by reconsideration of its action. A public hearing has been set for Oct. 8, 1912, when the question of the advisability of constructing such a line will be taken up, and advocates and objectors heard in public.

A Portion of U. S. Dam No. 26 on the Ohio River went out on Aug. 8 and caused damage now estimated at $60,000. This dam, located nine miles below the mouth of the Kanawha River, near Gallipolis, Ohio, is one of the series of dams now being built by the United States in the regulation of the Ohio River. It consists of a movable dam of the Chanoine wicket type for the navigable pass or channel, a weir of the bear-trap type for regulating the level of the upper pool and a masonry lock for the use of shipping when the dam is raised.

The entire structure was similar in design to Dam No. 37, on the Ohio River, which was described and illustrated in "Engineering News," Mar. 4, 1090, p. 234. Dam No. 26 was completed this summer, and the wickets of the dam raised on Aug. 6. On the morning of Aug. 7, nearly all of the 600 ft. of Chanoine wicket structure damming the navigable pass, moved downstream by sliding distances varying from nothing to 157 ft. from the original position. The Chanoine wickets were founded on a concrete slab, footing on shale rock. It is not now known whether the rock or the concrete sheared off, but it is reported that 129 out of the 150 wickets remained upright in their new positions, which would indicate that the failure was a shearing one somewhere below the base of the wickets.

The cost of the foundation of the pass, exclusive of the horses, props and wickets, is $61,091. The horses, props and wickets cost $43,110, but they were removed by a derrick boat in good condition and can be used again. It is estimated that the cost of repairs will then be about $60,000, which repairs have been authorized by Gen. Bixby, Chief of Engineers, U. S. A. The original appropriation for the lock and dam was $1,200,000, but it was built at a cost of $1,029,000, there being $171,000 still available. The work was done under the direction of the Corps of Engineers, U. S. A., by hired labor.

Personals

Mr. C. H. Dana, Assistant Engineer of the Gulf, Colorado & Santa Fé Ry., at Galveston, Tex., has been appointed Chief Engineer of the Union Terminal Co., Dallas, Tex.

Mr. F. Ringer, Assistant Chief Engineer of the Missouri, Kansas & Texas Ry. system at St. Louis, Mo., has been appointed Engineer of Maintenance-of-Way, with office at Parsons, Kan.

Mr. F. E. Foster, Roadmaster of the Southern Pacific R.R. of Mexico, at Culiacan, Mex., has been promoted to be Assistant Superintendent of the Sonora division and of the Sonora Ry., at Empalme, Mex.

Mr. Otis L. Jones, formerly Superintendent of the American Refractories Co., Joliet, Ill., has organized and is Manager of the Illinois Clay Products Co., which is now building a large plant at Oglesby, Ill.

Mr. Wm. A. Hunicke, Assoc. M. Am. Soc. C. E., has resigned his position as Construction Engineer of the Cuban Central Rys. to engage in private practice with offices at 302 Florida Life Bldg., Jacksonville, Fla.

Prof. James F. Kemp, of the department of geology, Columbia University, has gone to the Panama Canal Zone to make a special study of the geological conditions in the Culebra cut for the Isthmian Canal Commission.

Mr. R. E. Doolittle, who has been acting as Chief of the Bureau of Chemistry, U. S. Department of Agriculture, since the resignation of Dr. Harvey W. Wiley, has been appointed Chief of the Bureau of Chemistry by President Taft.

Mr. J. M. Oxley, Superintendent of the Chicago, Milwaukee & St. Paul Ry., at Des Moines, Iowa, has been appointed Superintendent of the Chicago division with headquarters at Chicago, Ill., succeeding Mr. L. R. Clausen, resigned.

Mr. C. I. Corp, of the engineering department of the University of Kansas, has been appointed Assistant Professor of hydraulics at the University of Wisconsin, succeeding Prof. George J. Davis, whose resignation was noted in our issue of July 11.

Mr. E. H. Holden, formerly Superintendent of the Kansas City Southern Ry., at Texarkana, Tex., has been appointed General Superintendent at Kansas City, Mo. Mr. R. R. Sutherland, Trainmaster at Shreveport, La., succeeds Mr. Holden at Texarkana.

Mr. R. D. Fitzmaurice, Trainmaster of the New York, New Haven & Hartford R.R., at New Haven, Conn., has been appointed Superintendent of the Western division at Waterbury, Conn., succeeding Mr. C. S. Lake, whose resignation was noted in our issue of last week.

Mr. Lewis Mims, formerly Assistant Superintendent of the Louisiana Western R.R. and of the Morgan's Louisiana & Texas R.R., at Lafayette, La., has been promoted to be Superintendent of the same roads, which are subsidiaries of the Southern Pacific Ry., succeeding Mr. E. E. Shackford, resigned.

Mr. Otis S. Lee, a Chinese civil engineer of San Francisco, Calif., and a graduate of the University of California and Columbia University, has been selected by the officials of the new Chinese Republic to take charge of important engineering work in modernizing some of the larger cities in China.

Dr. W. P. Gerhard, a consulting sanitary expert, of New York City, has been appointed the official delegate to represent the United States at the International Conference on Public and School Baths, to be held at Scheveningen, Holland. Dr. Gerhard will also attend the City Planning Exhibit at Düsseldorf, Germany.

Mr. Clemens Herschel, M. Am. Soc. C. E., a consulting engineer, of New York City, has been appointed Assistant to Lieut.-Col. W. C. Langfitt, Corps of Engineers, U. S. A., in connection with the hydro-electric development to be undertaken by the United States government at Great Falls on the Potomac River above Washington, D. C.

Mr. Charles H. Hawes, of Duluth, Minn., has been appointed Mine-Rescue Engineer of the Oliver Iron Mining Co. in Minnesota and Michigan. The office is a new one and will consist in maintaining a general supervision over rescue stations at all of the company's mines, the inspection of equipment, conducting of demonstrations, etc. Mr. Hawes was formerly with the U. S. Bureau of Mines.

Messrs. L. H. Guerin, recently Designing Engineer with Mr. J. F. Coleman, M.

Am. Soc. C. E., Consulting Engineer, New Orleans, La., and Samuel Young, M. Am. Soc. C. E., recently Engineer and Superintendent of Construction of the Rome Ry. & Light Co., Rome, Ga., have formed a partnership under the firm name of Guerin & Young for the general practice of engineering, with offices at 1002 Perrin Bldg., New Orleans.

The Southern Ry. has divided its Columbia division into two divisions. Mr. H. A. Williams continues as Superintendent of the new Columbia division and Mr. J. W. Wassum, formerly Superintendent at Charleston, S. C., is appointed Superintendent of the new Spartanburg division. The headquarters of both divisions will be at Columbia, S. C. Mr. W. C. Hudson, formerly Trainmaster at Knoxville, Tenn., succeeds Mr. Wassum at Charleston.

Mr. W. M. Noon, Superintendent of Bridges and Buildings of the Duluth, South Shore & Atlantic Ry. for twenty-odd years has resigned. Mr. Noon began railway work nearly half a century ago as a subcontractor for fuel wood on the Chicago, Milwaukee & St. Paul Ry., in the days when locomotives helped to consume the Minnesota forests. Later he took up railway contracting, making a specialty of bridge building. One of his many undertakings was the construction of a drawbridge over the Kinnikinic River, near Milwaukee, Wis., for the Chicago, Milwaukee & St. Paul Ry. He also constructed many early bridges on the Chicago & Northwestern Ry.

Obituary

Edwin Harris Burlingame, who 30 years ago was known as a water-works engineer, died on Aug. 5 at Ossipee, N. H., where he was spending the summer. His home for many years had been in Providence, R. I. He was born in Warwick, R. I., in 1836, the direct descendant of Roger Burlingame, who settled in Rhode Island in 1660. He received his education at the University grammar school in Providence and the Barre Academy, Barre, Vt., and began the practice of surveying before the Civil War. During the war he served with 11th Rhode Island Regiment and was promoted to the rank of First Lieutenant.

Following the Civil War, Mr. Burlingame again entered into engineering work, becoming Superintendent and Manager of the Norwegian Coal Co., Pottsville, Penn. Later he settled in Williamsport, Penn., where he was engaged in an independent engineering practice for several years. In 1881 he went to New York City and was employed in engineering work in connection with the Hudson River tunnel project. When this work was abandoned he settled in Providence and for a number of years was actively interested in the construction of water-works for several cities in the East and South. He had not been engaged in engineering work for a number of years before his death.

Engineering Societies

COMING MEETINGS

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Aug. 26-30. Annual convention at Peoria, Ill. Secy., Clarence R. George, Houston, Tex.

TRAVELING ENGINEERS' ASSOCIATION.
Aug. 27-30. Annual convention at Chicago, Ill. Secy., W. O. Thompson, N. Y. C. car shops, East Buffalo, N. Y.

INTERNATIONAL CONGRESS FOR TESTING MATERIALS.
Sept. 2-7. Sixth congress at New York City. Secy. of organizing committee, H. F. J. Porter, 29 West 39th St., New York.

MICHIGAN GAS ASSOCIATION.
Sept. 4-6. Annual convention at Toronto, Ont., and on board steamer "Rochester." Secy., Glenn R. Chamberlain, Grand Rapids Gas Light Co., Grand Rapids, Mich.

INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.
Sept. 4 at Washington.
Sept. 6-13 at New York City. Secy., Bernhard C. Hesse, 25 Broad St., New York.

AMERICAN ELECTROCHEMICAL SOCIETY.
Sept. 7-10. Annual meeting at New York City. Secy., Jos. W. Richards, Lehigh University, South Bethlehem, Penn.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES.
Sept. 9-12. Annual meeting at Hot Springs, Va. Asst. Secy., Walter Neumuller, 55 Duane St., New York.

ROADMASTERS' AND MAINTENANCE OF WAY ASSOCIATION.
Sept. 10-13. Annual meeting, Buffalo, N. Y. Secy., L. C. Ryan, C. & N. W. Ry., Sterling, Ill.

MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.
Sept. 10-13. Annual convention at Denver, Colo. Secy., A. P. Dane, B. & M. R.R., Reading, Mass.

COLORADO ELECTRIC LIGHT, POWER AND RAILWAY ASSOCIATION.
Sept. 12-14. Annual convention at Glenwood Springs, Colo. Secy., Thos. F. Kennedy, 900 15th St., Denver, Colo.

ILLUMINATING ENGINEERING SOCIETY.
Sept. 16-19. Annual convention at Niagara Falls, Canada. Secy., P. S. Millar, 29 West 39th St., New York.

NEW ENGLAND WATER WORKS ASSOCIATION.
Sept. 18-20. Annual convention at Washington, D. C. Secy., Willard Kent, Narragansett Pier, R. I.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Sept. 18-20. Annual meeting at Washington, D. C. Secy., Selskar M. Gunn, 755 Boylston St., Boston, Mass.

INTERNATIONAL CONGRESS ON HYGIENE AND DEMOGRAPHY.
Sept. 23-28. Fifteenth congress at Washington, D. C. Secy., John S. Fulton, Senate Annex, Washington, D. C.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
Sept. 24-26. Annual convention at Buffalo, N. Y. Secy., R. D. Moldenke, Watchung, N. J.

INTERNATIONAL ASSOCIATION FOR THE PREVENTION OF SMOKE.
Sept. 25-28. Annual convention at Indianapolis, Ind. Secy., R. C. Harris, City Hall, Toronto, Ont.

NATIONAL IRRIGATION CONGRESS.
Sept. 30-Oct. 3. Annual meeting at Salt Lake City, Utah. Secy., Arthur Hooker, Salt Lake City.

AMERICAN ASSOCIATION FOR HIGHWAY IMPROVEMENTS.
Sept. 30-Oct. 5. Annual convention at Atlantic City, N. J. Secy., G. E. Pennybacker, Jr., Colorado Bldg., Washington, D. C.

AMERICAN ELECTRIC RAILWAY ASSOCIATION.
Oct. 7-11. Annual convention at Chicago, Ill. Secy., H. C. Donecker, 29 W. 39th St., N. Y. City.

RAILWAY SIGNAL ASSOCIATION.
Oct. 8-11. Annual Convention at Quebec, Canada. Secy., C. C. Rosenberg, Times Bldg., Bethlehem, Penn.

American Road Congress — An announcement of this congress, to be held at Atlantic City, Sept. 30 to Oct. 5, was made in our issue of June 20. A feature of the congress since announced will be a conference of educational institutions under the direction of the Society for the Promotion of Engineering Education on the subject of courses of instruction for highway engineering students. At the present time there are approximately six institutions devoting some attention to highway engineering, although the instruction given in most instances is merely part of the general training. It is claimed that there is a considerable insufficiency of trained highway engineers to supervise the expenditure of $200,000,000 annually made in the United States for road improvement.

American Society of Civil Engineers—At the anual meeting of the Colorado Association the following officers were elected: President, Prof. M. S. Ketchum; Vice-President, A. O. Ridgway; Secretary and Treasurer, G. N. Houston. On July 8, J. A. Ockerson, President of the American Society of Civil Engineers, was entertained ,and on July 31, the Association had as guests Onward Bates, Past President, Am. Soc. C. E., and M. N. Baker, Editor of Engineering News.

Illuminating Engineering Society—At the 6th annual convention of the society to be held at the Hotel Clifton, Niagara Falls, Ont., Sept. 16-19, the following papers will be given: "Steel Mill Lighting," C. I. Munds; "High Pressure Gas Lighting," F. W. Goodenough; "Indirect and Semi-Indirect Illumination," T. W. Rolph; "Recent Developments in Series Street Lighting," Dr. C. P. Steinmetz; "Research Methods," E. P. Hyde; "Reflection from Colored Surfaces," C. W. Jordan; "Natural and Artificial Light Distribution in Interiors," M. Luckiesch; "Determination of Illumination Efficiency," E. L. Elliott; "Color Values of Illuminated Surfaces," Bassett Jones, Jr.

International City Planning Congress—Düsseldorf, in Germany, is to be the headquarters of this congress from Sept. 23 to 28. Commencing on June 29 last and ending Oct. 31 is an exhibition on city planning, city operation and city administration, which will be of especial interest to the delegates to the coming congress. Under city planning the exhibits consist of general ground plans, traffic systems, city embellishment, bridges, docks, parks, lawns, forests and real estate politics. Under city operation there are exhibits on gas-works, water-works, central electric stations, sewerage systems, street cleaning, refuse disposal, cemeteries and crematories. The exhibit on city administration includes plans and models of hospitals, rescue homes, poor houses, lodging houses, orphan asylums, schools, churches, museums, art galleries, libraries, concert halls, etc. Frank Koester, 115 Broadway, New York City, is cooperating in this country with the committee of the "Staedte-Ausstellung Düsseldorf.

International Association for Testing Materials—The Organizing Committee of the Sixth Congress of the Association has just issued an advance bulletin of the Congress, to be held in New York, Sept. 2-7, 1912. In addition to the eight technical sessions, six of which will be in three simultaneous sections, there will be numerous receptions and excursions in and around New York, and an official tour, Sept. 8-15, from New York, through Washington, Pittsburgh, Buffalo, Niagara Falls and back to New York.

Engineering Literature

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EDITORIAL

In the course of a review of Heck's "The Steam Engine and Turbine," on a following page of this issue, Prof. Lionel S. Marks says:

> It is doubtful whether a strongly individualistic book has good chances of success as a textbook. To be successful it has to be used by the average teacher and the average student, and if its mental processes are alien to them or difficult for them to follow, the book will not be largely used.

These remarks deserve careful attention by writers and by publishers of textbooks. They should not be construed to prohibit all novelty of material and of method, else new textbooks would be quite unnecessary. The material should be in at least general accord with the best knowledge of the time and the method of presentation should not be akin to a foreign language for teacher and student alike. Within some such limits as this the "individual outlook" on the part of the author is to be encouraged, since it will afford needed stimulus for both the instructor and those who are being instructed.

The latest thing in engineering-society journalism is a periodical published in two languages. The last two issues of the two-monthly *Journal* of the Society of Hungarian Engineers and Architects of America have each contained two leading articles, one printed in Hungarian and one in English. The English article in each case deals with engineering developments in Hungary, while the articles in the Hungarian language describe engineering work in America. The article on the development of the Hungarian natural-gas field, reprinted elsewhere in this issue, was prepared originally for the *Journal* in the form of an abstract or resumé of a number of articles in the Hungarian technical press, and was then translated by the Society's Secretary, who is also Editor of the *Journal*, from Hungarian into English. This plan seems well calculated to promote the international exchange of engineering knowledge and should appeal to other engineering societies in this country with a membership made up of beginners having a different mother tongue.

REVIEWS

Elliott's Drainage Engineering

REVIEWED BY A. MARSTON*

ENGINEERING FOR LAND DRAINAGE—A Manual for the Reclamation of Lands Injured by Water. By Charles Gleason Elliott, C. E., M. Am. Soc. C. E.; [formerly] Chief of Drainage Investigations, U. S. Department of Agriculture; Author of "Practical Farm Drainage." Second edition, rewritten. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 5x7½ in.; pp. 339; 60 text illustrations; 15 tables. $2, net.

Although entitled a second edition, this is really a new book, making the third on the same subject by the same author. Published at intervals of several years, by a man long recognized as foremost in American drainage, these three volumes constitute a very instructive exhibit illustrating the condition and progress of drainage engineering in the United States at different dates within less than the active lifetime of an engineer.

The first book was published by Mr. Elliott, in 1882, in association with the editor of a drainage journal devoted to promoting the use of drain tile, and was, as its title indicates, merely a brief treatise on "Practical Farm Drainage." The second book was published in 1902, just as Mr. Elliott took charge of drainage investigations for the U. S. Department of Agriculture. It gave a simple, elementary discussion of drainage engineering, well adapted to the days when the drainage engineer was just developing from the county surveyor, who had been proficient only in the running of land lines, and whose legal fee was $4 per day.

The book just published is a very great advance upon the others, and in the reviewer's opinion is the best treatise on drainage engineering now extant in the English language. It discusses the various phases of the subject in just the way likely to be most helpful to the American drainage engineer, who is still in the act of developing in the field a branch of the engineering profession dealing with construction work which, in Iowa alone, will certainly involve expenditures ultimately exceeding $100,000,000.

Especially to be commended are those parts of the book which discuss the drainage engineer, his standing and ideals.

The book is to be commended, also for the new data given as to satisfactory capacities of the drains. As to run offs actually observed in drainage areas of different size the book would be more valuable if the observations on which the curves are based were shown on the diagrams. The reviewer believes that the capacities of tile, stated by Mr. Elliott to be sufficient for Central Iowa, are too small. It is significant that the County Engineer of Boone County, for which the estimate of ¼-in. runoff in 4 hours, is quoted by Mr. Elliott, has found it necessary to adopt ⅓-in., as the result of his further experience. Many more actual gagings of runoff than are now available are needed by drainage engineers, and should be made by U. S. Drainage Investigations and the various State Experimental Stations.

It is to be regretted that the author still retains in his book old formulas for flow in pipes and ditches which have long since generally been abandoned by hydraulicians. This is the more serious because several actual gagings on tile drains and drainage ditches show flows 25% to 33% less than calculated by Mr. Elliott's formulas. Such actual gagings indicate that Kutter's formula, with n equal to 0.015 for tile drains and 0.030 for drainage ditches, gives excellent results for the average conditions met in practice. Moreover, unlike Mr. Elliott's "simple" formulas, Kutter's can readily be adapted to exceptional cases, and proper tables and diagrams make it as "simple" to use in actual calculations as any other.

Another error, also, unfortunately, giving too high a calculated flow for a given size, is Mr. Elliott's statement that it is proper to add an imaginary head in calculating main tile drains equal to b/n, where n is the number of sub-mains, and b is the sum of the products of the length of each sub-main by its excess of rate of grade over that of the main. Sub-mains require steeper grades than mains to give the same velocities, to say noth-

*Dean of Engineering, Iowa State College, Ames, Iowa.

ing of the serious interference of flow at tile junctions as ordinarily constructed.

Chapter XVI gives the best discussion of the important question of drainage assessments which the reviewer has seen anywhere. Drainage engineers need a handbook on legal phases of their work, giving the drainage laws of the different states, and a compilation of important court decisions.

Mr. Elliott's book includes brief chapters on "Levee Drainage Systems," "Reclamation of Tidal Lands," "Drainage of Irrigated Lands," "Drainage of Peat and Muck Lands," and "Control of Hill Waters," which are good, but not exhaustive enough to meet the needs of practicing engineers.

Summing up, every drainage engineer should own and study Mr. Elliott's valuable book, but there is still plenty of room for a much more exhaustive work on drainage.

Metallurgical Practice in the Rand

REVIEWED BY FRANK W. TRAPHAGEN*

A TEXT BOOK OF RAND METALLURGICAL PRACTICE—Designed as a "Working-Tool" and Practical Guide for Metallurgists upon the Witwatersrand and Other Similar Fields. By Ralph Stokes, Jas. E. Thomas, G. O. Smart, W. R. Dowling, H. A. White, E. H. JoJhnson, W. A. Caldecott, A. McA. Johnston and C. O. Schmitt. Vol. I. London: Charles Griffin & Co., Ltd. Philadelphia, Penn.: J. B. Lippincott Co. Cloth; 6¼x9 in.; pp. xix+468; 128 text figures; 124 tables. $6.50, net.

In this new book, although the field was apparently well covered by existing manuals, we have another very welcome addition. The plan of multiple authorship is excellent when, as in this case, the sections are handled by men whose experience has made them authorities in their particular lines. The practice is described in such a detailed manner and so clearly that anyone at all familiar with the cyanide process can introduce such changes as he may wish after a study of the book. The illustrations are excellent and so complete, in many instances being drawn to scale, that they could easily be used as working drawings.

This is the only book that may be considered as distinctly a Rand product, and it will be conceded that no district is better adapted to furnish the latest and best information concerning this process which was brought to its first successful issue and received its greatest commercial development in this great South African gold field.

There are so many excellent things in this book that the reviewer cannot forbear calling attention to some of the subdivisions, with occasional reference to some special points of interest.

CHAP. I—Introduction. The Witwatersrand and Its Mines. By Ralph Stokes.

*Professor of Metallurgy and Assaying Colorado School of Mines, Golden, Colo.

The production of 276 millions sterling and the distribution of 60 millions in dividends in 24 years of activity, broken by three years of warfare, is a triumph of achievement unsurpassed in the annals of metalliferous mining. The following are cited as the principal conditions which individually and collectively distinguish the Rand from the majority of other centers of gold production: High cost of skilled labor, low cost of unskilled labor, great magnitude of operations, simple composition and low average grade of ore. Although the Rand suffers to some extent from an absence of natural rainfall which is commonly utilized in hilly mining regions with ample water to obviate the mechanical elevation of products to positions commanding the units or plant, the field gains over many others by the often unlimited space available for the erection of plant and disposal of residues. This availability of abundant "elbow room" is an important consideration. The Rand's foremost company, the Crown Mines, Ltd., has a reef-bearing area eight times that of the entire group of Kalgoolie's producing companies, which are huddled together on the famous "Golden Mile."

Containing some 3% of pyrite, the silicious ore is capable of treatment without marked metallurgical complexities. With sufficiently fine grinding to expose the gold incased in the sulphides, virtually any percentage of extraction is obtainable, but the economic limit of residue value is at present about 0.3 dwt. per ton, beyond which it costs more to save the gold than the extra recovery is worth. This residue value corresponds to an extraction of 95.5% on average ore.

It will certainly be admitted that the Rand has been conservative in regard to the adoption of many mechanical devices and chemical reagents to recover more gold, which devices are highly economical in other mining districts with costly unskilled labor, with ore of more complex composition and higher grade and with otherwise divergent local conditions.

The Rand is now milling 21,500,000 tons per annum. At this rate the estimated remaining quantity of 1,464,000,000 tons would give a life of 80 years, if allowing for a gradual decrease in annual production during the last two decades. On the assumption of tonnage made, the Rand's total yield—including £276,000,000 already produced—would exceed £2,000,000,000.

An important factor contributing toward the successful administration of the Rand mining industry has been the incident of a strong local control tending to safeguard the mines from technical interference at the hands of distant financial influences. Rand directorates, composed for the most part of men thoroughly conversant with local conditions and appreciative of working difficulties, take an active part in the framing of technical policies. They are advised at headoffice by the group of consulting engineers—mining, mechanical and metallurgical. At the mine the manager generally has unrestricted authority and responsibility in the regulation of current operations.

CHAP. II.—Sorting and Breaking. By James E. Thomas.

Sorting was introduced on the Rand by J. H. Johns, of the Ferreira G. M. Co., in 1892, and since then has been generally adopted. The sorting is done on revolving tables or traveling belts, speeded about 30 ft. per min., the waste being picked out by hand and rejected. Sorting, where about 15% is rejected, costs about 5½c. per ton milled.

Breaking is done by Blakes or gyratories, or combinations of these, the aim being to furnish the stamps with 2-in. material.

CHAP. III—Stamp Milling. By G. O. Smart.

The subject is very thoroughly covered in this section and numerous important suggestions derived from local practice are given. The advent of the tube-mill has materially affected the function of the stamp battery. Primarily devised to secure all the gold possible by amalgamation and in this direction to crush as finely as practicable, it is now taking its place as a preliminary fine grinder, the aim now being to secure the coarsest of the gold by an initial grinding and amalgamation followed by finer grinding in tube-mills with or without a second amalgamation preceding the cyanide treatment. By this combination it has been possible to greatly increase the capacity of stamps, at the same time increasing the total recovery.

The removal of the finer material from the feed to the stamps has been found to greatly increase their duty. In this connection, while an apparent effort is noted throughout the book to use the term "mesh" in the sense of number of openings per linear inch, yet occasionally the old English practice of giving the openings per square inch is reverted to and the reader is hereby warned to be on his guard whenever "mesh" is mentioned.

The general tendency in building battery foundations is toward the use of concrete mortar-blocks, and we believe that even when timber is more plentiful than in South Africa this will become the common practice. When one remembers that in a battery of stamps falling 100 times each per minute, a distance of 8 in., nearly three-quarters of a million blows per day are received by the mortar and its supporting block, the necessity for strength and rigidity is apparent, and the great monoliths of concrete weighing upward of 100 tons used for each two batteries will be conceded to be important features of the crushing plant.

The admission of water to the mortar at five points, each directly opposite a die, results in increased capacity mainly

by the removal from the die of material fine enough to pass the screen. Inside amalgamation has been abandoned on the Rand as well as nearly everywhere else, with a greatly increased milling capacity as a direct result.

The loss of metal from shoes, dies and other parts amounts to about ½ lb. per ton of ore crushed. Much trouble is encountered from the deposit of insoluble salts in service pipes throughout the mills and to avoid this difficulty as far as possible the pipes are made so large as to permit a considerable filling up before their capacity is reduced below requirements. This trouble is, of course, due to the use of the alkaline service water derived from the cyanide plant.

Wire-cloth, instead of slotted or punched plates, is universally used for battery screens. This is possible because of the use of the alkaline water just mentioned, no difficulty being encountered from corrosion.

CHAP. IV. Tube Milling. By W. R. Dowling.

The advent of tube-milling on the Rand dates from 1904. The use of classifiers for the removal of material already sufficiently fine for cyaniding is an important factor in the success of this fine-grinding stage. In addition to this removal of the excess of water or solution from the sand which is to be further ground is essential, for a too wet or too dry material cannot be as economically ground as one with just the requisite quantity of water. The invention of the diaphragm cone has made it possible to control within very close limits the character of the products, both overflow and underflow, so that practically any required product may be furnished.

The crushing efficiency of tube-mills is much greater when fed with coarse pulp than with fine. In coarse-crushing trials carried out at the Simmer East and Simmer Deep plants, it was found that the tube-mills produced from 133 to 137 tons of 0.006-in. product per tube-mill per 24 working hours, against only 107 tons when running under normal conditions—an increase of over 23%.

CHAP. V. Treatment of Sand. By James E. Thomas.

The diaphragm conical classifier has proved a very important adjunct in the separation of slime from the finely crushed sand, and its use enables the securing of a perfectly leachable product under the most trying conditions. Details of construction are given, showing the various types of distributors, collectors, pumps and filters. Lead acetate and lime, the latter in sufficient amount to secure ample protective alkalinity, are constantly used.

Tailing is largely used for stope filling, and as some residual cyanide is always present, it becomes necessary to use some cyanicide to destroy it, to prevent poisoning of underground workmen. Potassium permanganate, about 0.08 lb. per ton of tailing, is effectively used.

CHAP. VI.—Slime. Part I. General Considerations. By H. A. White. Part II. Works Practice. By W. R. Dowling.

In aiding the clarifying of solution with the coincident settling of slime, lime is one of the most important agents. It is also useful in destroying and precipitating cyanides, in causing increased extraction on the battery plates, chiefly, however, at the expense of the slime value, and the ready return of classified water to the mill circuit. It must be constantly renewed, because of its continuous removal as carbonate and sulphate. Ordinary pyritic banket usually requires about 6 lb. of lime per ton of slime to maintain the required alkalinity.

The rate of slime settlement is greatly enhanced by heating the solution and several plants have already introduced schemes for the utilization of the waste heat from engines for this purpose.

CHAP. VII. Precipitation. By E. H. Johnson.

Zinc, the first material to be used for the recovery of gold and silver from cyanide solutions, is still the almost sole precipitant used. Having its ascendency for a while, especially with weak solutions, threatened by electrical methods, since the use of the zinc-lead couple, it has still held practically undisputed possession of this field. Zinc-dust precipitation has not yet been adopted on the Rand.

CHAP. VIII.—Clean-up and Smelting. By E. H. Johnson.

Zinc-filament precipitation being universally used on the Rand, the clean-up is conducted in much the same manner as elsewhere. The use of the trommel zinc washer would appear to greatly simplify the operation of separating the gold precipitate and shorter zinc from the longer fibers.

The most interesting feature of this section is the discussion of the use of acid sulphate of sodium in place of the almost universally used sulphuric acid. The use of acid sulphate or bisulphate would seem to be superior for a number of reasons, among which are the following: Cheaper, no poisonous fumes or disagreeable odors evolved and no tendency shown by the charge to boil over.

As is generally customary, so on the Rand the melting down of the acid-treated precipitate is almost always done with suitable fluxes in large graphite crucibles.

CHAP. IX. Assaying. By A. McA. Johnston.

The methods of arranging or organizing the work are discussed, as well as the methods of performing it.

CHAP. X.—On Testing. By A. McA. Johnston.

This chapter covers very thoroughly the testing solutions, of supplies, the various tests to be applied to gold ores to determine the applicability of amalgamation and cyanidation to any particular ore and finally the various tests to be applied to working plants to discover efficiency of operation or weaknesses of any part of the process.

CHAP. XI.—Chemistry of Banket Ore Treatment. By W. A. Caldecott.

A very excellent closing chapter by Dr. Caldecott is given over to a consideration of the nature of Banket ore, chlorination, weathering of pyrites, amalgamation, dissolution of gold in cyanide solution, oxidizers, behavior of ferrous compounds, lead salts, lime, precipitation of gold, reactions in zinc boxes, clean-up, smelting of cyanide bullion, reactions of cyanide residue after discharge, treatment of residue dumps and sand filling of mines.

CHAP. XII. Tables. Compiled by W. A. Caldecott and H. A. White.

This includes the following: Antidote for cyanide poisoning, logarithmic tables, powers, areas of circles, mensuration, formulas for falling bodies, weights and measures, innumerable other tables and a number of sample report blanks.

As a whole the book will be found not only useful but practically indispensable to the cyanide man.

PROBLEMS IN ENGINEERING WITH SOLUTIONS—Being questions and answers reprinted from the "Assistants' and Students' section of the "Surveyor and Municipal and County Engineer." First Series, 1909-10. Edited by Sydney G. Turner, Assoc. M. Inst. C. E. London: St. Bride's Press, Ltd. Cloth; 5x7½ in. Pp. 186. Numerous text illustrations. $2 (5/- net).

The English journal, *The Surveyor and Municipal and County Engineer*, carries on a section devoted to various questions which might be put in an examination for the position of municipal engineer in an English town or city. The questions are given one week and answers provided by various correspondents given in subsequent issues. The volume noted above is the first one to be made up from these questions and answers. As is well known, the position of municipal engineer in England is one of most varied activity, so that the subject covered by the questions and answers extends through the whole field of engineering. For example, the chapter headings are as follows: Mechanics and Hydrostatics; Strength and Elasticity of Materials; Theory of Structures; Surveying and Leveling; Water Supply and Hydraulics; Sewerage; Sewage Disposal; Road Making and Tramways; Building Construction and Materials; Law and Miscellaneous. While the questions and most of their solutions are distinctly British in character, the wide range of subjects and the method of treatment make the book of some value to American engineers. There is a good deal to be said in favor of the question and answer method of instruction.

A New Text-Book on the Steam Engine

Reviewed by LIONEL S. MARKS*

THE STEAM ENGINE AND TURBINE—A Text-Book for Engineering Colleges. By Robert C. H. Heck, M. E., Professor of Mechanical Engineering, Rutgers College. New York: D. Van Nostrand Co. Cloth; 6x9½ in.; pp. xi + 631; 402 text figures; many tables. $5, net.

The appearance of a new college textbook on the steam engine from the pen of Prof. Heck, so soon after the publication of his two-volume textbook on "The Steam Engine and Other Steam Motors" would seem to suggest that the earlier work had not proved itself entirely adapted to its intended use. Both the earlier and the present works are important books; they contain the products of much patient analysis of experimental and experiential observations on steam appliances, and constitute a noteworthy attempt to bridge, by various empirical means, the gap between the indications of the elementary theory of steam motors and the results obtained in actual operation. The earlier two-volume work is probably too compendious and monumental to be a satisfactory textbook. In these respects it resembles the two-volume work on the same subject by Prof. Thurston which was well known by an earlier generation of engineering students. In all other respects, however, the similarity ceases. Thurston's work was discursive and verbose to an extraordinary degree, and seldom brought any matter to a definite conclusion. Heck's is keenly analytical, keeps very much to the point, and presents always to the reader that empirical relation which is found by the author to best represent the result of practice.

The present work is not merely an abridgment or adaptation of the earlier work, but is in large part a rewriting. The field covered is more restricted. It deals with thermodynamics, the properties of steam, ideal steam cycles, the action of the steam in the cylinder, the performance and efficiency of steam engines, the working and construction of the engine, valve gears and governors, the action of the steam in turbines, the design and construction of turbines and with various steam auxiliaries.

The markedly individual outlook of the author is reflected in all parts of his book, but does not cause him to deviate from generally approved methods of presenting the subject. It is doubtful whether a strongly individualistic book has good chances of success as a textbook. To be successful it has to be used by the average teacher and the average student, and if its mental processes are alien to them or difficult for them to follow, the book will not be largely used. Good examples of this are the textbooks of Prof. John Perry. These books are extraordinarily stimulating to minds which are not cast in the conventional mold, but they have not recommended themselves to the average American teacher, though it is probable that the less trained and therefore less-conventional mind of the average student would find them very congenial.

The preliminary descriptive treatment of the steam plant is an excellent introduction to the whole subject. This is followed by a simple development of the elementary theory of heat engines, and a chapter on the properties and behavior of steam with which is associated a series of new steam tables and charts which are properly located in the appendix. The utility of these tables and diagrams is distinctly impaired by the lack of adequate headings and legends. The special feature of the next chapter is the analysis and discussion of the phenomena of the steam jet, for the elucidation of which various tables of properties are presented and some interesting and novel material has been deduced. The chapter on the action of the steam in the engine occupies nearly 90 pages and contains the results of much analysis of researches on cylinder condensation and on compression; the author suggests that this is a portion of the book which can very properly be abbreviated in the classroom. The performance of actual engines is similarly subjected to a painstaking analysis in the following chapters, with the result that much valuable information is gathered together on engine efficiencies, on engine friction and on diagram factors.

The chapters on the working and construction of the engine take up the forces in the machine, the motion of the engine mechanism, the working force, flywheel action, the pressures on pins and bearings, balancing, and a description of actual constructive details; the chapter on valve gears and governors takes up the actions of all the more usual types. The problems of proportioning the parts for strength are not considered here.

The discussion of the steam turbine, though not as detailed as that of the reciprocating engine, is still fairly complete in so far as relates to the design of the steam passages and to the performances of steam nozzles and of the turbine as a whole. Here also is much collection and analysis of tests of nozzles and of turbines.

The final chapter presents an uptodate statement of condenser practice with an analysis of the performance of a number of common and of special types.

The utility of the book as a whole suffers occasionally from a lack of lucidity both in the methods adopted and in expression. These are, however, but minor blemishes. On the whole the author is to be congratulated on having produced a book which should prove serviceable as a textbook and which also must be referred to by whoever is seeking light on the actual performance of the steam engine.

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ELEMENTARY APPLIED MECHANICS—By Arthur Morley, M. Sc., M. I. Mech. E., Professor of Mechanical Engineering in University College, Nottingham, and William Inchley, B. Sc., A. M. I. Mech. E., Lecturer and Demonstrator in Engineering in University College, Nottingham. London, New York, Bombay and Calcutta: Longmans, Green & Co. Cloth; 5x7½ in.; pp. 382; 261 text figures. $1, net.

The method of presenting the ideas of elementary mechanics which has been adopted in this book is intended for readers with little knowledge of mathematics other than arithmetic. The various principles are generally introduced by means of numerical examples before being expressed in the form of algebraic formulas.

The numerical examples are supplemented in many cases by illustrations and descriptions of simple experiments. The outcome of the experiments is given and conclusions drawn therefrom, after which the general principle covering the case is stated. This method has the merit of following the natural development of our knowledge of physical laws, that is, the principles are given as deductions from a number of individual experiments. The book is particularly suited for those having a very limited previous training in mathematics and physics.

The introduction gives information on the calculation of areas, densities, etc., and on methods of measurement used in the workshop and laboratory. Apparently it is expected to serve in a measure as a laboratory manual for such experiments as are commonly performed in a course in elementary physics laboratory work.

The American Electric Railway Association, in order to promote desirable publicity for its work in the interests of the street and interurban railways of this continent, has decided to publish a monthly periodical. It will be called the *Aera*, and will contain contributed articles on general questions affecting the industry and on matters of more immediate interest to the engineers, accountants, claim agents, and traffic officers. Another section will be devoted to association news; still another will be a question box, and a fourth will give the personnel of the working committees of the parent and affiliated associations.

The first issue appears this month and contains articles, among others, from T. N. McCarter, Public Service Ry., of Newark, N. J.; W. B. Brockway, Ford, Bacon and Davis, of New York; J. S. Doyle, New York Railways Co., of New York City; C. G. Rice, Pittsburg Railways Co.; J. N. Shannahan, Newport News & Old Point Ry. & Electric Co., of Norfolk, Va.

The publication is sent without charge to all members and extra subscriptions are supplied at $2 per year.

A Large History of a Small but Notable School

NORWICH UNIVERSITY, 1819-1911—Her History, Her Graduates, Her Roll of Honor. Published by Major-General Grenville M. Dodge, C. E., A. M., LL. D. Compiled and edited by William Arba Ellis, B. S., A. M. In three volumes. Vol. I: General History, 1819-1911. Vol. II: Sketches of the Trustees, Presidents, Vice-Presidents, Professors, Alumni, and Past Cadets, 1820-66. Vol. III: Sketches of the Trustees, Presidents, Vice-Presidents, Professors, Alumni, Past Cadets, Honorary Graduates and Under-Graduates, 1867-1915. [Address Norwich University, Northfield, Vt., for particulars of publication.] Cloth; 6x9½ in.; pp. xx + 604; xxii + 772; xxv + 760, respectively; illustrated.

Probably most engineers of the younger generation have never heard of Norwich University. There are, however, both in engineering work and in business life some hundreds of successful men who are proud to call it their Alma Mater.

While the history of the institution itself has been a checkered one, its early graduates included a remarkable number of men who rose to high rank in the pioneer days of American engineering. This is the best proof that the school's work in the early days of military and engineering education in this country was far from unimportant.

Norwich University now lacks only seven years of its century mark.

The institution owes its foundation to Capt. Alden Partridge, who graduated at West Point in 1806, and was a professor there for the following eleven years, being Superintendent of the Academy in the years from 1815 to 1817. Captain Partridge was an educator much in advance of his time. Soon after the conclusion of his term of service at West Point, he resigned his Commission to found a private institution for instruction in military science and engineering, selecting a site in his native town of Norwich, Vt., which was and is a quiet farming town in the Connecticut Valley, just across the river from Hanover, N. H., the seat of Dartmouth College. At that period "academies" were the popular educational institutions and Captain Partridge named his school "the American Literary, Scientific and Military Academy." Though located in this remote spot, the school had an immediate success. Four years after its establishment it had enrolled 162 students, representing 18 states and three foreign countries.

With all Captain Partridge's ability as an educator, however, there appear to have been eccentricities in his character which soon brought the school into difficulties. Only six years after its foundation in Norwich, Captain Partridge removed the school to Middletown, Conn., where new buildings were constructed from money raised by the sale of stock in the school. It was attempted to place the institution on a better financial basis by obtaining power from the legislature "to confer degrees, award diplomas and raise by lottery $40,000 for chemical, astronomical and philosophical apparatus and for a library and buildings." The legislature refused to grant this.

Apparently dissensions arose among the owners and managers of the school, resulting finally in the sale of the buildings in 1829 to the Methodist Church as the beginning of what is now Wesleyan University. Captain Partridge returned to Norwich and opened an elementary school there, which continued for two or three years, when the Academy was again moved to Norwich. It seems to have led a rather shadowy existence in its old home, however, until 1843, when it was chartered as "Norwich University" by the legislature of Vermont. Its ambitious title, however, did not save it from more or less continuous financial trouble for a long period of years. There appears to always have been some friend or other, however, who would come forward in the nick of time to save the institution from shipwreck, and so it continued its existence with a varying number of students until 1866 when it was removed to Northfield, Vt., in the central part of the state. Here it has remained ever since.

While it has had to meet the competition of the University of Vermont, at Burlington, and Middlebury College, at Middlebury, as well as Dartmouth College, near its old home, it has succeeded in maintaining itself, and through the generosity of its alumni and other friends has, in recent years, greatly improved its financial standing. In the years from 1885 to 1911, it registered a total attendance of 937, of which 294 were graduated.

The compilation of the three volumes of this history represents an enormous amount of labor, which has been without doubt truly a labor of love on the part of the compiler, W. A. Ellis. Justification is found in the important part which the early graduates of the university played in developing the field of military education and in doing pioneer work in the field of engineering at a time when engineering education in the United States was in its infancy. As an illustration of this latter fact, we take at random the following list of names of prominent engineers of the earlier days who were graduates of this institution: General Grenville M. Dodge, of the class of 1851; Moncure Robinson, 1824; Franklin Wright, 1834; Edward D. Adams, 1864; William H. Greenwood, 1852; Benjamin S. Marsh, 1836; James E. Ainsworth, 1853; William B. Gilbert, 1828; Edwin F. Johnson, 1825; Harris B. Henry, 1864; Samuel T. Wellman, 1866; Alfred W. Craven, 1825; George H. Derby, 1842. The service which these and other prominent alumni of the University have rendered to the profession is the best justification for the work which has been done in compiling this history.

FIRE PREVENTION—A Treatise and Text Book on Making Life and Property Safe against Fire. Written for "The Chief," the Government Weekly. By Peter Joseph McKeon, Consulting Expert in Fire Prevention. New York City: The Chief Publishing Co. Cloth; 6x9 in.; pp. 256; many text figures. $1.75, net.

A text written "for inspectors, fire marshals, business men, building managers, shop foremen, superintendents of institutions, janitors, engineers, matrons and housekeepers" can hardly be expected to furnish much new information to structural engineers, architects and construction superintendents, and the book before us is more popular than technical.

After a short historical account of the development of fire-prevention work, which was originated by and has been largely developed by the mutual factory insurance associations, the author takes up the description of "fire appliances and their uses," or in other words *fire-protection* devices, such as automatic sprinklers, standpipe fixtures, watchman service, etc., rather than the most important means of *fire prevention*, which is, of course, safe building construction.

No small part of the book is descriptive of the standards for fire doors, window covers and fittings recommended and specified by the National Fire Protection Association.

What to do in case of fire and how to put out a small fire are chapters treating in clear, plain language much that housekeepers should know well and thoroughly. Common-sense directions and descriptions of various little devices for lessening the danger of fire in dwelling houses make the book well worth while for those classes of people for whom it is intended.

Were every housekeeper to fully appreciate the importance of taking such precautions as are described in this book, the annual fire loss per capita in this country might not be, as it is at present, several times larger than that of any European country.

THE MANUAL OF STATISTICS—Stock Exchange Hand-Book, 1912. 34th annual issue. New York: The Manual of Statistics Co. Cloth; 5½x8 in.; pp. xxv + 1098. $5, net.

The 34th annual issue of this publication appears with practically no change of arrangement of the subject matter in former issues, nor has there been any important additions. It gives in a general way the reports of the leading steam railways of the United States regarding their financial operation, the rate of dividends paid, the executive officials, the names of the Board of Directors. In the case of the larger roads, statistics are given of the freight traffic, but these are by no means general. Financial reports are also given of the leading industrial corporations, including mining companies, and in the appendix is a table showing the price of various securities on the

leading stock exchanges of North America, as well as some valuable statistics regarding the produce market and the use of various crops.

Physical Chemistry

Reviewed by C. F. BURGESS*

THEORETICAL AND PHYSICAL CHEMISTRY—By S. Lawrence Bigelow, Ph. D.; Professor of General and Physical Chemistry in the University of Michigan. New York: The Century Co. Cloth; 5½x8¾ in.; pp. 544; 81 text illustrations. $3, net.

As between chemistry and physics, the prevailing methods of instructions produce notably differing results. The average man ten years out of college remembers more of his physics than he does of his chemistry. The reason for this is not that chemistry has a lesser relationship to everyday life or a lesser inherent importance, but it is due evidently to the essentially different methods of instruction which are followed in presenting the two subjects.

Before the fundamental principles of chemical phenomena can be presented, it appears necessary that more or less familiarity with chemical reactions and properties must be assumed, and in accord with this idea the author in presenting this work on Theoretical and Physical Chemistry addresses it to those who have to their credit "half learned and three-fourths forgotten" courses in general and analytical chemistry.

The ideal book on physical chemistry should bring order out of chaos as to facts, laws, generalization and theories developed in the modern field of chemistry. Admiration for courage and congratulations for results may well be recorded this author in dealing in an analytical way with this new field of science which is in a rapidly developing and transitional stage.

The entire field of physical chemistry is covered in a comprehensive way, first, by dealing with the principles of philosophy as applied to the study of chemistry; second, with the "ultimate constituents" of matter; third, with the properties of substances; and fourth, with the process of transformation.

To anyone having an elementary knowledge of chemistry, whether he be an undergraduate student or a practicing chemist, this book should be of interest and value. It encourages a broader attitude toward the study of chemistry than is afforded in many textbooks and attempts to dispel the impression that a knowledge of "higher mathematics" is necessarily a foundation upon which the studying of physical chemistry must be based. To the thinking educated but unscientific public, this volume does not constitute interesting reading. It shares with a great mass of chemical literature, the handicap of employing a language which the ordinary reader has not learned.

An appreciation of a valuable contribution, such as Dr. Bigelow has made to American literature, might well be expressed without dwelling on minor defects, such as are bound to be present in any extensive compilation. A subject of major importance, however, is "energy" and a teacher who seeks to convey to his students a concrete idea of energy would not be helped by the author's definition that energy is "whatever leads us to believe that something exists outside our own conscientiousness," as much as he would by the more usual definition which the author deprecates, viz., "ability to do work." We cannot agree that the term "electricity" should be avoided as implying something which we may isolate, while the terms "heat" and "light" are allowed to retain a respectable standing. A serious error, confusing to students, is a definition of a coulomb as a unit of electrical energy. This leads the author to an erroneous and misleading presentation of Faraday's law.

As appealing to the majority of students, there is no doubt that applicability of subjects studied to practical problems and everyday life is a tremendous stimulus to interest and understanding and in the possession of this quality the book is notably deficient.

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THE MODERN LOCOMOTIVE—By C. Edgar Allen, A. M. I. Mech. E.; A. M. I. E. E. London: Cambridge University Press. New York: G. P. Putnam's Sons. Cloth; 5x6½ in.; pp. 174; 36 cuts in text. 40c.

This little book is a condensed outline of the features of design, construction and performance of the locomotive of today; it deals mainly with English practice, although certain special features of continental and American practice are mentioned. Reference is made to the developments in size and power necessitated by demands for faster trains and more commodious (and heavier) cars. But in England a passenger train of 200 to 350 tons is considered very heavy. Some long non-stop runs are mentioned but, strange to say, their lengths are not given, except that they are all over 100 miles. In order to secure the necessary power without excessive cylinder size several English railways are using three-cylinder and four-cylinder simple engines, a notable type being the four-cylinder 4:6:2 engines of the Great Western Ry.; these have all cylinders 15x26 in.; 80½-in. drivers, and 60 gross tons adhesion weight.

As to compounding, the author considers it difficult to account for its unpopularity in England, in view of the results of actual performance, and he considers it superior to superheating as a means of effecting economy. Of valve gears, we find three (Stephenson, Walschaerts and Joy), all used on English railways.

It is surprising to find what a wide range of subjects can be covered in this condensed treatment; not only is the engine itself dealt with, but also such subjects as stability, resistance, performance, economy, etc. But although the book is brief and presents merely a review of the subject, it has a literary style and a readable quality not always to be found in larger and more pretentious works. And it certainly gives to the reader a fair idea of developments and features which mark the modern locomotive.

THE INITIATIVE, REFERENDUM AND RECALL—Edited by William Bennett Munro. National Municipal League Series. New York and London: D. Appleton & Co. Cloth; 5x7¾ in.; pp. viii + 365. $1.50, net.

The rapid growth of the initiative, the referendum and the recall in the West, their eastward march in connection with commission government and the strong advocacy now taking place for their general adoption in state and federal affairs all combine to make this book timely. The fifty-page introduction by Professor Munro very properly presents arguments and opinions both for and against these measures of popular control, but with an apparent leaning to the negative. The bulk of the volume is composed of essays, mostly reprints, by Colonel Roosevelt, Governor Woodrow Wilson, President A. Lawrence Lowell and Prof. Lewis J. Johnson (both of Harvard) Senator Jonathan Bourne, Jr. (Oregon), Congressman Samuel McCall (Massachusetts) and others. There is a brief reference list. A comprehensive index also deserves mention. The book is a worthy addition to the National Municipal League series of publications on current municipal and allied topics.

BULLETIN OF U. S. DEPARTMENT OF AGRICULTURE, No. 107 (Forest Products Laboratory Series)—Henry S. Graves, Forester. "The Preservation of Mine Timbers." By E. W. Peters, Engineer in Wood Preservation. Washington, D. C.: Pub. Doc. Paper; 6x9¼ in. Pp. 27; 4 plates, 7 text figures.

This bulletin reviews in a brief manner the advantages of wood-preservative methods in increasing the durability of mine timbers, and reports various tests which have been made to determine the value of various preservatives in preventing decay, attacks of insects, etc. Curiously enough, no mention is made in the report, so far as we have been able to find, as to the effect of certain preservatives, such as creosote, on the inflammability of the timbers. It is well known that creosoted timber is exceedingly inflammable, and the dangers of fires in mines are serious enough already without adding anything to the hazard. According to this report, however, since-

chloride treatment is as efficacious as creosote in preserving mine timbers which are not exposed to water so that the preservative is dissolved out. It seems probable that timber treated with zinc chloride might be even less inflammable than untreated timber; so that the report might well be supplemented by further information discussing mine-timber preservation from this practical point of view.

The Secret of Success

THE HUMAN FACTOR IN WORKS MANAGEMENT—By James Hartness, M. E., M. Am. Soc. M. E.; Inst. Mech. E.; Fellow Am. Assoc. Ad. Science. New York and London: McGraw-Hill Book Co. Cloth; 5¼ x 7½ in.; pp. 159. $1.50, net.

The author of this little book is well known as a successful engineer, inventor, manufacturer and executive. This volume shows that beside these accomplishments he is a philosopher. The key-note of the little volume is found in the first entry under the Table of Contents, "Success depends more on the man than the plan."

At this particular time, when systems of "efficiency engineering" and "scientific management" of various brands are being widely promoted, it is refreshing and we believe distinctly useful to have such doctrines put forward as those laid down by Mr. Hartness in this book. While Mr. Hartness in this book is thinking of and talking of machine-shop administration, the principles he lays down are applicable to a wide range of industries.

There are very few men occupying positions of executive responsibility who, if they will read carefully and ponder thoughtfully the suggestions in this book, will not find themselves broadened thereby.

The first two chapters of the book treat respectively of the "value of habit" and the "inertia of habit." Other philosophers have been for years dinning into our ears so continually the evils of bad habits and the necessity of uprooting bad habits in industrial organizations that it is distinctly refreshing to have someone come forward and defend habit as an excellent thing in itself.

It should not be understood, however, that Mr. Hartness is a reactionary. On the contrary, he is a progressive; but a progressive who has found that successful progress depends upon making advancement in the directions where advancement is easiest and most profitable.

Mr. Hartness's suggestions cover such a range of ground that it is difficult to give a comprehensive idea of them within the limits of a brief review. We may note, however, that one common fallacy which he punctures is the idea that all men want the same thing in life. Mr. Hartness says:

> The man, who from a lofty position in this world, feels a desire to lift up everyone into a more strenuous life is like the boy who gave his grandmother a trumpet and drum for a Christmas present. He thinks others want what he wants. But this is not the case. There are men who lead the happiest lives in other ways. There are many men on earth who do not want their brains racked with perplexing problems and who are willing and glad to do any work that is wholesome providing they can get a good livelihood. Such contentment is not understood by one who is built by nature to thrive in an environment of responsibility. He thinks this contented fellowman is lazy. He does not know that there is little or no laziness in this world of the kind that term usually implies.

Part II of the book entitled "Some Non-Technical Phases of Machine Design," is a reprint of an address before the Engineering Society of the Stevens Institute of Technology. In this Mr. Hartness lays down the best methods psychologically for the successful inventor to pursue. The chapter is worth careful study, not only by those engaged in the actual work of machine design, but also by those who employ engineers for this class of work, who often do not realize that really good, original and valuable work in this field cannot be turned out on the 8-hr. or 10-hr. a day plan.

In Part III, "Machine Building for Profit," the author discusses some of the methods by which a concern in the machinery trade can make or lose money very rapidly.

We believe Mr. Hartness' book is a valuable and much needed contribution to the literature of "scientific management."

ILLUMINATION—Its Distribution and Measurement. By Alexander Pelham Trotter. London: Macmillan & Co., Ltd. [New York: The Macmillan Co.] Cloth; 5½x9 in.; p. 292; 210 text illustrations; tables. $2.75, net (8/6, net).

The reader of Mr. Trotter's book should see from the title at once that it is not intended to be a general treatise for designing the illumination of a particular case in hand. It is rather almost entirely an analysis of existing illumination schemes and the recital of the ways in which illumination may be measured.

Everyone who has followed Mr. Trotter's career as an engineer has, of course, recognized that his favorite hobby has long been illumination; his book, moreover, shows all the interest and enthusiasm we might expect. Indeed the origin of this book may be traced back 20 years to a paper presented before the British Institution of Civil Engineers. In this paper Mr. Trotter proposed ways and means of studying illumination which are very remarkably like those which have been gradually developed since then. On this account perhaps the author may be excused for the evident touches of pride and picturesque expressions.

The book starts out with a description of various units and standards of candlepower and of illumination. This is followed by sections showing the graphical determination of illumination on various planes and surfaces from different arrangements of light sources. Then the reader is plunged into photometry and carried through descriptions of all the important features of apparatus used for measuring the candlepower of torches and the intensity of illumination on surfaces.

THE WESTINGHOUSE AIR BRAKE SYSTEM—Containing Detailed Descriptions and Explanations of all the Various Parts of the Westinghouse Air Brake. Compiled and edited by the world's leading air brake experts. Chicago, Ill.: Frederick J. Drake & Co. Cloth; 5½x8¼ in.; pp. 487; many colored charts and 110 text figures. $2, net.

This differs from other books of instruction for those who have to do with the operation of air brakes in being more a treatise than a handbook. It is too large to be conveniently pocketed and its style is less condensed and perhaps more explicit than that found in books of the catechism type. The catechism feature is represented here too, however, by long lists of examination questions and answers designed to fit the student to pass any "examinations to which he may be subject in the line of promotion." The information in these questions and answers duplicates that in the descriptive and explanatory passages, which accounts for the size of the book.

The numerous illustrations include colored charts making clear the distribution of air at different pressures and steam in the various pipes and passages of the apparatus. The equipment covered includes the 8½-in. cross-compound air pump; No. 6 E T equipment, high-pressure control, schedule U; the K-triple, E-triple and L N equipment; combined automatic and straight air brake, and the 1¼-in. pump governor.

REPLANNING SMALL CITIES — Six Typical Studies. By John Nolen, Fellow American Society of Landscape Architects. New York: B. W. Huebsch (225 Fifth Ave.). Cloth; 6½x10 in.; pp. xii + 218; 44 illustrations. $2.50, net.

The author of this book has become well known for his work in preparing plans and reports for the improvement of various American municipalities. In this book are given condensations or abstracts of reports made by the author on half a dozen such cities, namely, Roanoke, Va., San Diego, Calif., Montclair and Glen Ridge, N. J., Reading, Penn., and Madison, Wis. A brief introductory chapter discusses the general principles involved in replanning small cities and the same subject is further considered in Chapter VIII. In general, as would be expected, the point of view is rather that of the landscape architect than the engineer. The chief features considered in connection with the city plans are the lay-out of streets, location and provision for parks and playgrounds, location of civic centers, etc.

Probably the most useful part of the book is the appendix, which is devoted to reprints of various ordinances, legislation, etc., with relation to city planning. It is interesting to note that most of these originated in Massachusetts and Wisconsin. The book is printed in large type on heavy paper with broad margins, so that the total amount of matter contained in it is much less than would be supposed from a cursory examination.

An American Ironmaster

THE AUTOBIOGRAPHY OF JOHN FRITZ—New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6x9 in.; pp. 327; 21 text illustrations. $2, net (9/6 net).

John Fritz will be 90 years old on Aug. 21. To have lived so long in the center of the American iron and steel district would alone have qualified any mechanical engineer to write interestingly of the remarkable developments which have taken place there within the last three-quarters of a century. How interesting such a book may be when it comes from the hand of one who has had so much to do with these developments can be imagined.

In a few short chapters, in a straightforward, simple style, John Fritz tells us of his boyhood life on a Pennsylvania farm, when his schooling was intermittent and exceedingly meager. At 16 years of age he became an apprentice to learn the trade of blacksmithing and country machine work. From this point on, John Fritz has kept in the background; his story of the search for experience and knowledge in the art of iron and steel making and working takes the reader through the various plants that then existed and gives an excellent idea of the crudeness and the lack of scientific knowledge and methods with which the work was conducted.

The mastery of all that others knew of the iron business did not satisfy John Fritz, and he set about to devise methods and means entirely new and untried. But he early established a reputation for not making mistakes. He lived up fully to the rule: Be sure you are right and then let nothing stand in the way. He was sure of the success of his innovations before he undertook them. He had the confidence that can come only from thorough knowledge. He himself says, "I laid down an absolute rule not even to suggest anything new or untried until I had satisfied myself that it was all right and was a proper thing to do; consequently I was well fortified and was in a position that was at all times impregnable."

An example of this is shown in the following incident, which we give in the language of the author:

> At the time when we were in the midst of our improvements at Cambria, a banker to whom the company owed $20,000, came into the rolling mill and asked me what we were doing. I told him that we were making changes and improvements. His reply was that any man that would destroy property and spend money as we were doing was a fool or a madman. I told him that I was doing it and it had never occurred to me that I was either. He took the train that night for Philadelphia and the next morning called at the company's office and demanded his money in such an emphatic manner that they had to pay him that day.

In speaking of the Cambria Iron Works, of which he was manager in 1854, he also writes: "Energy, determination and patience of a staying quality were the great requisites for doing work under the then existing conditions."

It is needless to say to those who are already familiar with the life of John Fritz that every incident in his life shows the possession of all these virtues. It is needless also to add that a man who possessed such justifiable confidence in his own work in time won the confidence of his employers as few men have done before or since.

We trust that the few short extracts we have given show, in a small measure, what the reader of this book may expect. To review it in detail would be to retell the life of John Fritz in a much less interesting and instructive way than that in which he has written it.

The autobiography of John Fritz is a book which should be in every engineer's library; it is a book which should be read by every engineering student. In simplicity, frankness and modesty of style and for the wisdom it contains, this book can well be likened to the autobiography of Benjamin Franklin.

About two-thirds of the book is taken up by the autobiography and the remaining one-third by a description of the Fritz Engineering Laboratory, at Lehigh University, and an account of the anniversary dinner given John Fritz at Bethlehem, in 1892, and the John Fritz banquet in New York, in 1902.

COURS DE PONTS METALLIQUES: PONTS SUSPENDUS (Treatise on Metal Bridges: Suspension Bridges)—By Jean Résal, Inspecteur Général des Ponts et Chassées. Paris: Ch. Béranger (15 Rue des Saints-Peres). Paper; 6½x10 in.; pages, 197, 27 text figures. Francs, 6; American price, 90c.

Like some other works by this author which we have had occasion to review, it is of a purely theoretical and mathematical character; it contains not a single reference to or illustration of any particular bridge, and its few illustrations are simple diagrams. It deals largely with the author's own methods of calculation of stresses for suspension bridges with and without stiffening trusses, the latter class including continuous and noncontinuous trusses.

The first chapter (48 pages) deals with the calculations for bridges of both classes, together with a note on bridges having towers of equal height. The second (83 pages) deals with the theory of oscillatory and vibratory movements, the movements of the cables, and the influence of stiffening trusses upon the stability. The third (34 pages) gives numerical calculations, based upon the formulas and methods set forth in the preceding chapters. The fourth chapter (15 pages) discusses the adjustment of length of suspenders and the use of diagonal cables extending from the towers to the stiffening trusses.

A PLAN OF THE CITY OF HARTFORD—Preliminary Report by Carrére & Hastings, Advisory Architects to the Commission on the City Plan of the City of Hartford, Conn. Paper; 6x9 in. Pp. 117. Numerous illustrations and maps.

The day before the accident which resulted in his death, John M. Carrére, of the firm of Carrére & Hastings, signed the report on the plan for the city of Hartford, which makes up the best part of the book noted above. This plan is, therefore, the last contribution to city planning of an architect whose widest fame lay in the design of buildings but who in recent years had attained just recognition for his work in the layout of cities.

The plan of the city of Hartford was undertaken by the firm of Carrére & Hastings, at the instance of a city plan commission authorized by a legislative act, and the more recent additions to the city public buildings and street extension are a result of this commission's work. The plan outlined by the consulting firm is ambitious, as are all such plans, but appears to be more nearly possible of fulfillment than many of the ideal schemes which professional city planners set forth. Already the city of Hartford has an enviable position as regards its layout and park systems, and the adoption of the new plan would put it well ahead of the cities of the second class in this country in this respect.

A second supplement to the 1908 edition of the Iron and Steel Works Directory has been recently issued by the American Iron and Steel Association (James M. Swank, General Manager, 261 South Fourth St., Philadelphia, Penn.). This and its predecessor, issued in 1910, bring down to the close of 1911 the essential information on new iron and steel works completed or undertaken since the publication of the 1908 directory, and on important changes in the ownership and equipment of plants previously described.

This new supplement contains also a complete list of all blast furnaces in existence or under construction in the United States at the end of 1911 and a separate list of abandoned or dismantled furnaces. A new feature is a list of electric furnaces and ferro-alloy plants identified with or dependent upon the iron trade.

For complete information on the iron and steel works of the country, one needs the 1908 directory and both the 1910 and 1912 supplements. No new edition of the directory itself will be published this year. The comparatively high price of the new supplement ($5 for 80 pages) is accounted for by its limited circulation and the amount of laborious effort required for its compilation.

Aeronautics

PRACTICAL AERONAUTICS—An Understandable Presentation of Interesting and Essential Facts in Aëronautical Science. By Charles B. Hayward, M. Soc. Auto. Engrs. and Aëronautical Society; formerly Engineering Editor "The Automobile." With Introduction by Orville Wright, Chicago, Ill.: American School of Correspondence. Cloth; 6½x9¾ in.; pp. xiii + 769; 310 text figures. $3.50, net.

BUILDING AND FLYING AN AEROPLANE—A Practical Handbook Covering the Design, Construction and Operation of Aëroplanes and Gliders. By Charles B. Hayward, M. The Aëronautical Society, and Society of Automobile Engineers, Chicago, Ill.: American School of Correspondence. Cloth; 5½x8½ in.; pp. viii + 142; 52 text figures. $1, net.

The larger volume is cumbersome in size but not in internal structure; it is a well digested readable compilation. Much of it necessarily covers familiar ground, but a great deal of the matter has not been presented before so as to show its relative importance. As would be expected from the title, theory is made secondary to practice, but sufficient theory is presented in simplified form to enable the average reader to understand the reasons for certain peculiarities of construction which are turned out. The illustrations are commendable, particularly the clear and artistic line cuts.

The author quickly passes over balloons, giving scant attention even to dirigibles. The most space is allotted to the Wellman, Vaniman and Zeppelin ships.

The subject of aviation proper is approached historically and then the author shifts to a discussion of the theories of dynamic flight. He first shows a ready acceptance of the old formula for resistance pressure:

$$P = 0.0054\,V^2$$

(noting, however, that experiments show a coefficient of 0.0060). Nevertheless, we can logically deduce the expression

$$P = 0.0027\,V^2$$

for sharp angles of incidence, and a longer but still simple and logical expression for approach to the horizontal, in place of the empirical formulas of Duchemin and Eiffel. The more logical expressions have not been widely discussed as yet, and, of course, this volume could present only investigations which have been fully published.

Under the heading, "Types of Aëroplanes," is found a description of the Wright, Curtiss, Voisin, Farman and Cody "standard" biplanes, and the Antoinette, Santos Dumont, Bleriot, Grade and Pfitzner "standard-type" monoplanes, together with a comparison of several features of them. Then follow descriptions of special patterns—freak machines, we might say—and that latest development, the hydro-aëroplane. The volume contains also some well chosen descriptions of all the prominent makes of engines for flying machines. There is much about the design of propellers and a little about their construction.

The author gives space to descriptions of automatic lateral stabilizers and to the benefits which will be secured by lessening the duties of the aviator. The means described of measuring altitudes will be familiar reading to any engineer.

There is a long discussion of the patent situation; that is, a discussion of the validity of the Wright basic patent. The author seems to be firmly convinced of the validity of the Wright brothers' claims, basing his belief, we should judge, on the principle that their patents cover the first successful flying machine, and any previous inventions showing the same elements on inoperative machines give no valid claims.

Many other sections must needs be passed over briefly, such as the chapters on civil law related to aëronautics, the military importance of the aëroplane, wireless telegraphy from flying machines, etc.

One leading section, filling about a quarter of the total space, is on "Building and Flying an Aëroplane." The author has picked out typical examples like the Curtis and Bleriot machines to give drawings of the details of construction and a description of the ways in which the machines are fabricated. The would-be constructor is advised to begin his efforts with a small model, plans and directions for such being printed first. After this the reader is led to construct a motorless glider and then the larger power-driven machines.

It is at once evident that this must be an expensive pastime even for one who does all the work laid out. A careful reading of the directions shows that no little mechanical skill is necessary and considerable more shop equipment than the average reader can hope to possess. These handicaps are all made clear, however.

After the machine is built the author's warning is not yet to fly. "Take a few lessons of an experienced aviator," is his first injunction. For those who cannot or will not follow this advice, he outlines the gradual steps through which safe flight can be approached—manoeuvering on the ground, then at a few feet above the earth, and in calm weather.

Toward the close of the book the notable accidents have been tabulated, together with their causes. This forms the basis of a discussion of the lessons to be learned by amateurs from the recklessness of victims and the structural weaknesses of machines.

The second book noted at the head of this review is a reprint of the final portions of the larger work.

THE NAVAL POCKET-BOOK—Founded by Sir W. Laird Clowes. Edited by R. C. Anderson. Corrected to Apr. 27, 1912. With numerous sketches and plans. London: W. Thacker & Co. Calcutta and Simla: Thacker, Spink & Co. Cloth; 3½x5 in. Pp. 734. 7s. 6d. net. American price, $3, net.

Anyone carrying a copy of this book and a pair of binoculars should be able to identify all war vessels likely to be met in any waters, and having named the boat, he could tell the number and caliber of its guns and the thickness of its armor, as well as its general dimensions and speed.

In addition to conveniently tabulated particulars of all ships of any account in the navies of all nations, the book contains a list of the world's dry docks and tables giving dimensions, powder charges, etc., of the guns and small arms of different nations. There is also a series of metric conversion tables.

The chief feature of this edition of the book is the introduction of outline sketches showing the arrangement of funnels, masts and guns of the ships of all navies.

CENTRAL STATION HEATING—By Byron T. Gifford, M. Am. Soc. of Heating and Ventilating Engineers; Jr. M. Am. Soc. M. E. New York: Heating and Ventilating Magazine Co., 1123 Broadway. Flexible leather; 5½x9 in.; pp. 208; 37 text illustrations; many tables. $4, net.

Mr. Gifford has brought together material to cover a wide scope of activity for the central-heating-company engineers and officers. He recites general advantages, cares of management, points of good franchises, and outlines pipe-line design, arrangement of station and consumer's equipment, features of maintenance and operation, basis of rates, etc. There is a large appendix of weights and measures, heat equivalents, mensuration tables, properties of materials, etc.

ANNUAL REPORT OF THE LIGHTING DEPARTMENT, SEATTLE, WASH., 1911—With a Review of the Work Since the Inception of the Seattle Municipal Light and Power Plant. Compiled by J. D. Ross, Superintendent. Seattle, Wash.: Pub. Doc. Paper; 7x10 in.; pp. 123; illustrated.

This annual report has been given more elaborate form and greater statistical completeness than is usual with such documents. In addition to the expected financial statements there is a description of the development of the Cedar Lake municipal project, with photographic reproductions of lake, falls, dams, pipe lines, power houses, etc., and of the city streets and buildings, and factories using city power, together with portraits of all the prominent men identified with the work.

Refuse Destructors

MODERN DESTRUCTOR PRACTICE—By W. Francis Goodrich, Assoc. Inst. M. E. F. Inst. San. E.; Author of "Refuse Disposal and Power Productions," "Small Destructors for Institutional and Trade Waste," etc. London; Charles Griffin & Co., Ltd. Philadelphia, Penn.; J. B. Lippincott Co. Cloth; 6x9 in.; pp. xvi + 278; 116 text figures; 46 tables. $4.50, net.

Mr. Goodrich has formed the habit of writing a new book instead of attempting the difficult task of bringing an old one uptodate. Accordingly we now have his "Modern Destructor Practice" as a successor to "Refuse Destructors and Power Production," which, in turn, succeeded "The Economic Disposal of Towns' Refuse." (The two earlier books were reviewed in our issues of Aug. 18, 1904, and Sept. 19, 1901, respectively.) In general plan the volume before us follows very closely the book which appeared eight years ago. Meanwhile, the author's experience and viewpoint have been broadened by the lapse of time, by travel and observation, including a trip to America, and by dissociation with the British makers of refuse destructors with whom he was for some years connected and by devoting his time to private engineering practice.

It is only fair to restate that in view of the author's position at that time the book reviewed almost exactly eight years ago "showed a remarkable freedom from bias in discussing different makes of British furnaces." His attitude toward British destructors has not changed materially, if at all, since then, but his criticism of American types of furnaces is softened at some points and he also appears to be more favorably disposed toward American garbage-reduction plants. If he still fails to do the latter full justice, as we feel he does, he may be partly excused in view of the fact that his subject is refuse destructors.

The book opens with a few pages on tipping, or, as we should say, dumping, refuse on land and in water, and on pulverizing it for the production of fertilizing material. The latter practice is considered as economically doubtful, while tipping, especially on land, is condemned as not only unsanitary, but as a serious menace to health. Here the one-time salesman gets the better of the engineer, as in the earlier book, and we again read such newspaper stories as the following:

> The inquest of the body of William Webbe, laborer, who died on the refuse tip in Waterloo Road, Cardiff, yesterday, was held this afternoon, when medical evidence showed that the deceased succumbed to heart disease, accelerated by the heat and the smell from the refuse.—"South Wales Echo."
>
> A report was presented to the committee, showing that within a radius of 200 yd. from the existing tip there had been 14 cases of scarlet fever and 8 cases of diphtheria—two of the latter proving fatal—in a period of 18 months. —"Flixton Telegraph."

More worthy of credence is a statement a Dr. Nash, when medical officer of health for Southend-on-Sea, came to the conclusion, "after much patient investigation," that a high rate of mortality near refuse tips "was due to the contamination of food by flies from the refuse tips entering the open windows of the adjacent houses." But the only warrant for credence here is that the conclusion was reached "after much patient investigation." If full data were available it would probably be shown that the refuse and the flies played only a minor part, if any real part, in the high mortality in question.

Fortunately only a few pages of the volume are occupied with such stories.

The author next takes up, in succession, types of British destructors, systems of charging, including front, back and top feed; destructors combined with sewage works and with electricity works, of which there are a surprising number; various British installations, described briefly; destructor sites, specifications for destructors, and questions of design and operation, and utilization of residuals. Finally, a chapter devoted to foreign and colonial installations, including welcome information regarding German furnaces, and a chapter onpractice in the United States and Canada, round out the volume.

The author is a firm believer in the economic value of the utilization of heat from refuse destructors. Many figures are presented in support of that belief, but not all of them are sufficiently complete to be convincing. Furthermore, doubt is thrown upon their conclusiveness by the author's own remarks on the unreliability or incompleteness of much of the British municipal accounting. That the authorities of many British cities believe that it pays to utilize the heat from refuse destructors there can be no doubt. We do not so much question that heat utilization may pay in many instances as deplore the paucity of the data on the subject. It is only fair to add that the author appears to have used "due diligence" in gathering and presenting such financial data as are available; although perhaps he might have given more figures of first cost. Such figures, with more specific and more extended figures on depreciation, would be of value for other purposes than for studies of the economics of heat utilization.

Finally, we take pleasure in commending the book as an exposition of the British refuse destructor, as viewed by an engineer who has had intimate experience with one of the most successful types and has taken great pains to inform himself of the best that has been achieved by British and foreign designers and builders of destructors. At the same time we feel compelled to say that with the exception of specialists or those who wish the latest word on the subject, it will hardly be worth while for many of those who possess the author's treatise of 1904 to buy a volume which, notwithstanding the change in name and in publisher, is after all a well revised or rewritten edition of an old book rather than a strictly original treatise. This, however, will not greatly lessen the number of Americans who will find it advantageous to own the book.

ELECTRICAL METERMAN'S HANDBOOK—Written and Compiled by the Committee on Meters, National Electric Light Association; O. J. Bushnell, Chairman. New York: The Association. Cloth; 4½x6¾ in.; pp. 1026; 730 text figures. $2 to members; $3 to nonmembers. Reduction on quantities.

The uninitiated might suppose that this book, from the title, was only another of the numerous disseminators of "practical" information for workingmen. Even the most casual examination dissipates any such incomplete impression and the preface tells us that the National Electric Light Association has compiled the volume. "To supply such information as is needed in training men for meter work (of central station companies) together with such instructions and data as every meterman should have constantly at hand for reference."

We would expect, therefore, that these would be a wide variety of theoretical discussion and practical description. Expectation is satisfied. The elementary presentation of electrical theory comes early in the chapters on "Nomenclature" and "Principles of Meters." While the schemes of actual use on circuits are given under "Measurement of Energy." Alternating currents have to be discussed here and the mathematical expressions ought to stagger the average meterman; we remember, however, that the book is intended to be supplemented by the explanations of the head of the meter department. Following this matter are sections showing, good meter-laboratory and shop equipment and practice, and others giving information on the more important commercial types of electricity meters.

A question arises at once in the electrical engineer's mind about the relation of this handbook to the Meter Code of the National Electric Light Association. Investigation shows that the latter is for central-station management, public-utility commissions, etc., being specifications for the acceptance of meters and auxiliary apparatus, for the general means and ends of tests, repairs, etc. There is but slight overlapping the two texts.

The paper on "The Relative Corrosion of Iron and Steel Pipe as Found in Service," presented before the New England Water Works Association (address Tremont Temple, Boston, Mass.) on Dec. 13, 1911, by Prof. Wm. H. Walker, has been printed in abstract as bulletin 10 (July, 1912) of the National Tube Co. (Frick Building, Pittsburgh, Pa.).

A British Book on the Engineering Equipment of Public Buildings

ENGINEERING WORK IN PUBLIC BUILDINGS—Power, Lighting, Heating, Ventilation, Water Supply. A reference book for all engaged in the design and construction of asylums, hospitals, colleges, hotels and other large institutions. By R. Owen Allsop, Architect; author of "Public Baths and Wash-Houses," etc. London: E. & F. N. Spon, Ltd. New York: Spon & Chamberlain. Cloth; 8½x11 in.; pp. viii + 158; 75 text figures. $5, net.

Whatever the usefulness of this book to engineers in Great Britain, we have been unable to see where an engineer in American practice could derive any benefit from its use, either for study or reference. The machinery in use in public and private buildings for heating, ventilation and water supply and other household requirements is so radically different in the two countries that practice in Great Britain is no guide to work in this country. For example, chapters 3, 4, 5 and 6 of the present book, occupying pages 34 to 60, are devoted respectively to "Vertical Boilers for Institutions," "The Cornish Boiler," "Lancashire Boilers," and "The Dry-back Boiler." With the exception of the first named, not one of these boilers is in use in the United States. The following chapter, which is devoted to water-tube boilers, indicates the hold which precedent has upon British engineering practice. The author argues that "in certain special installations serious consideration should be given to the claims of the water-tube boiler." It appears from this chapter that while for electric lighting stations the water-tube boiler has become very popular in Great Britain, the conservative people who control public institutions are not at all inclined to look with favor on any such new fangled idea!

The chapters on steam heating and hot-water heating are comparatively brief and we find nothing regarding the late refinements of vacuum systems, heat regulating systems and so on which have done so much to revolutionize heating work in the United States. Turning to the chapter on ventilation we read this sentence: "Left to himself every medical superintendent would depend on fire for heat and open windows for ventilation. On fundamental principles he is correct and no amount of argument would convince him otherwise. As a type the English open fire and open windows are unapproachable despite the adverse criticism."

With this attitude of mind, it is easy to see why practice in the heating and ventilation of buildings, large and small, shows so wide a variation in Great Britain and the United States. The chief thing which an American "Institutional Engineer," as this book terms him, can gain by reading this volume will be the satisfaction of his curiosity as to the general manner in which things are done on the other side of the water, or rather in the tight little isle of Great Britain.

Statistics

AN INTRODUCTION TO THE THEORY OF STATISTICS—By G. Udny Yule, Honorary Secretary, Royal Statistical Society of London. London: Charles Griffin & Co., Ltd. Philadelphia, Penn.: J. B. Lippincott Co. Cloth; 5¼x7¾ in.; pp. xiii + 376; 53 figures and diagrams. $3.50, net.

Statistics as a dry product of administrative red tape are not very attractive. But as the raw material from which technical advances are produced, the premises on which vitally important conclusions are based, statistical matter is not only abstractly interesting but of personal importance to the engineer. From railroad operation and planning to public health administration and public-works projecting, nearly all branches of the professional service have close relation to statistics. The engineer, who must at all odds avoid the evil state in which statistics are the highest degree of the lie, requires to study the systematic and accidental errors of statistics, methods of averaging and of correcting averages, and finally the principles governing the assignment of weights. He must use mental operations similar to those used in dealing with instrumental observations. The surveyor—especially the geodetic surveyor—is well prepared to engage in such study.

Where statistics ends, and where economics (or other higher subject) begins, is rather hard to define. To determine whether railway freight operating comparisons should be based on train-mile, ton-mile, or other unit, might be regarded as a matter for the economist to settle; but really it is purely a matter for the statistician. For, the statistician is not primarily a counter, but a classifier. Before he can count he must know in what columns and groups he is to distribute the check-marks; and this distribution cannot be arbitrary, but must be based on the nature and conditions of that particular collection of statistics. When the railway executive directs his accounting department to classify and analyze their operating figures in a particular way, he exercises the statistician's function. The order will breed confusion unless it is based on a correct and abstruse analysis of the conditions governing the origin, ultimate meaning, and method of ascertainment, of the particular figures in question. As a mere railway executive it is beyond his province to prescribe the proper classification.

The study of the subject of statistics is highly intricate; this justifies the term "theory of statistics." That the larger part of existing collections of figures has been compiled and used without knowledge of such theory may have a great deal to do with the unsavory reputation enjoyed by statistics. Constant improvement made in this direction permits the hope that in time we may be able to depend with more assurance than hitherto on conclusions drawn from statistics. For example, health records may in time be so improved that the simple subject of waterborne-disease statistics will be freed from the contradictions and chance for misleading deductions now found in it.

Incidentally, this latter example may help to bring to mind the great complexity of modifying factors affecting even the simplest statistical problem.

Yule's "Introduction" is a highly intelligent and easy-reading work, not free, however, from abundant occasion for close thinking. We may single out those chapters which promise to have most interest for the engineering student, by mention of title, to indicate the material it offers the reader.

Three chapters on Association and Classification will start thought on independence and interdependence of variables. They are not of direct use to the engineer, but will serve mainly by preparing his mind for appreciation of statistical difficulties, and by awakening certain analogies to awkward and illegitimate curve-plotting often found in technical writings. Several chapters centering on Averaging should prove of much practical use, however. The difference between the several forms of means is important in all fields, and even though the reader may not require to use the principles there learned in his own work, he will be enabled to pass opinion on the merit of others' statistical conclusions. The third part of the work, on Sampling and the error curve, will also prove matter of special interest to the engineer, with the limitation that the examples are drawn from fields beyond his personal touch.

There is ample room for more literature on the subject. Somewhat less of theoretical analysis, and more of practical discussion, with illustrations from technical operations, would make an excellent companion volume to this one, for the engineer's study.

Publications Received

[So far as possible the name of each publisher of books or pamphlets listed in these columns is given in each entry. If the book or pamphlet is for sale and the price is known by the editor the price is stated in each entry. Where no price is given it does not necessarily follow that the book or pamphlet can be obtained without cost. Many, but not all, of the pamphlets, however, can be secured without cost, at least by inclosing postage. The amount of postage necessary can be estimated approximately from the stated size of the book or pamphlet and the number of pages it contains. Reprints of papers read before engineering societies and printed by the authors for private circulation can often be obtained without cost by addressing the author, whose name and address is always given when known. Persons who are in doubt as to the means to be pursued to obtain copies of the publications listed in these columns should apply for information to the stated publisher, or in case of a reprint of a society paper to the author of the paper. The stated American prices of foreign books are based on 40 cents per shilling and per mark for British and German books, respectively, and 30 cents per franc for French books, the extra allowances being for importation costs.]

ANALYSIS OF METALLURGICAL AND ENGINEERING MATERIALS—A Systematic Arrangement of Laboratory Methods. By Henry Wysor, B. S., Assistant Professor of Analytical Chemistry and Metallurgy in Lafayette College; Consulting Chemist and Metallurgist. Easton, Penn.: The Chemical Publishing Co. London: Williams & Norgate (14 Henrietta St., Covent Garden, W. C.) Cloth: 8½x10½ in.; pp. 82. $2, net.

THE BOARD OF GAS AND ELECTRIC LIGHT COMMISSIONERS, MASSACHUSETTS—Annual Report, 1911. Boston, Mass.: Pub. Doc. No. 35. Paper: 5¾x9 in.; pp. 239; with Appendices, pp. 441.

BRANDKATASTROPHEN UND BRANDSCHAEDEN IN DEN VEREINIGTEN STAATEN, DEREN URSACHEN UND WIRKUNGEN—Eine wirtschaftliche Studie von Ing. Michael J. Nagel. [Band 19, "Abhandlungen aus dem Gebiet der Feuerversicherungswissenschaft," herausgeber Dr. Wilh. Schaefer.] Hanover: Carl Brandes. Paper; 5¾x8½ in.; pp. 56.

BULLETINS, U. S. GEOLOGICAL SURVEY—George Otis Smith, Director. Washington, D. C.: Pub. Docs. Paper; 5¾x9 in.; illustrated.

Nos. 530-N and O: Advance chapters from Bulletin 530, "Contributions to Economic Geology, 1911, Part I."

N—Gypsum in Utah and Virginia. By C. T. Lupton and G. Stose. Pp. 37.

O—Sulphur in Utah, Wyoming and Colorado. By F. L. Hess, E. S. Larsen and J. F. Hunter. Pp. 25.

THE BUSINESS OF MINING—A Brief, Non-Technical Exposition of the Principles Involved in the Profitable Operation of Mines. By Arthur J. Hoskin, M. E., Consulting and General Mining Engineer; Western Editor "Mines and Minerals." Philadelphia and London: J. B. Lippincott Co. Cloth; 5x7¾ in.; pp. 224; 18 text figures. $1.50, net.

CENTENARY LECTURES—Delivered at the Celebration of the First Commercial Gas Co. to Sell Gas as an Illuminant, held at the Franklin Institute, Philadelphia, Penn., April 18-19, 1912. Edited and Published by the American Gas Institute, New York City. Cloth; 6x9 in.; pp. 174; illustrated.

CINEMATIQUE APPLIQUEE ET MECANISMES—By L. Jacob, Ingénieur Général de L'Artillerie Navale, Directeur du Laboratoire Central de la Marine. Encyclopedie Scientifique series. Paris: Octave Doin & Fils (8, Place de L'Odeon). Cloth; 4¾x7¾ in.; pp. 400; 171 text figures. Francs 5; American price, $1.50, net.

THE ELECTRIC CIRCUIT—By V. Karapetoff. Second Edition, rewritten, enlarged and entirely reset. New York and London: McGraw-Hill Book Co. Cloth; 6x9½ in.; pp. 229; 55 text figures. $2, net.

ELECTRIC LIGHTING AND MISCELLANEOUS APPLICATIONS OF ELECTRICITY—A Text-Book for Technical Schools and Colleges. By William Suddards Franklin. New York: The Macmillan Co. London: Macmillan & Co., Ltd. Cloth; 6x9 in.; pp. 299; 200 text figures. $2.50, net.

ELECTROLYTIC PURIFICATION OF SEWAGE—By F. C. Caldwell, Professor of Electrical Engineering, Ohio State University, Columbus, Ohio; Honorary Member of Ohio Electric Light Association. [Presented at Convention of Ohio Electric Light Association, Cedar Point, Ohio, July 16-19, 1912.] Paper; 6¼x9¼ in.; pp. 7. Address the author.

ENTWICKLUNGSGESCHICHTE UND THEORIE DES EISENBETONS—Erster Band des "Handbuches für Eisenbetonbau." Zweite Auflage. Bearbeitet von M. Foerster, Max R. von Thullie, A. Kleinlogel, J. Melan, O. Graf, Ph. Völker, E. Richter. Herausgegeben von Dr. Ing. F. von Emperger. Berlin: Wilhelm Ernst & Sohn. Paper; 7¼x10¼ in.; pp. viii + 665; 900 text figures. Marks 25; geb., 28; American price, $10 and $11.20, net.

FIRE PREVENTION AND FIRE PROTECTION AS APPLIED TO BUILDING CONSTRUCTION—A Handbook of Theory and Practice. By Joseph Kendall Freitag, B. S., C. E., Assoc. M. Am. Soc. C. E.; Author of Architectural Engineering," etc., New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Leather; 4½x7 in.; pp. 1038; 395 text figures. $4, net.

FORESTRY IN NEW ENGLAND—A Handbook of Eastern Forest Management. By Ralph Chipman Hawley, Assistant Professor of Forestry, Yale University, and Austin Foster Hawes, State Forester of Vermont and Professor of Forestry, University of Vermont. New York: John Wiley & Sons. London: Chapman & Hall, Ltd. Cloth; 6x9½ in.; pp. 474; 140 text illustrations. $3.50, net.

FRESH AIR AND HOW TO USE IT—By Thomas Spees Carrington, M. D., Assistant Secretary of the National Association for the Study and Prevention of Tuberculosis; Author of "Tuberculosis Hospital and Sanatorium Construction." New York: The Association (105 E. 22d St.). Cloth; 5¼x8 in.; pp. 250; 150 text figures. $1, net.

GAZETTEER OF SURFACE WATERS OF CALIFORNIA—Part I: Sacramento River Basin. Prepared under the direction of John C. Hoyt. By R. D. Wood. Water-Supply Paper 295, U. S. Geological Survey; Geo. Otis Smith, Director. Washington, D. C.: Pub. Doc. Paper; 5¾x9 in.; pp. 99.

GEOLOGY AND ORE DEPOSITS OF THE BUTTE DISTRICT, MONTANA—By Walter Harvey Weed. Professional Paper 74, U. S. Geological Survey; Geo. Otis Smith, Director. Washington, D. C.: Pub. Doc. Cloth; 9¼x12 in.; pp. 262; 41 plates (25 in pocket) and 109 text figures.

HOUSING CONDITIONS IN FALL RIVER—Report prepared for the Associated Charities Housing Committee, by Carol Aronovici, Ph. D., Director of the Bureau of Social Research of New England. Fall River, Mass.: The Committee. Paper; 7x10 in.; pp. 29; illustrated.

KARSTGEBIETE UND IHRE WASSERKRAEFTE—Eine Studie aus Oeffentlichen Vorträgen des Verfassers über die Ausnützung und Verwertung der Wasserkräfte in den Karstländern der Ost.-Ung. Monarchie. By Theodor Schenkel, Behördlich Autorisierter Zivil-Ingenieur U. St. Beeid. Sachverständiger. Wien and Leipzig: A. Hartleben. Cloth; 7x10½ in.; pp. 91; 125 illustrations. Marks 8; American price, $3.20, net.

LES NAPPES AQUIFERES DE FRANCE Essai D'Hydrogéologie. Par le Dr. Ed. Imbeaux, Ingénieur en chef de la Ville de Nancy. Extrait de la Revue "La Technique Sanitaire et Municipale." Paper; 8¼x11¾ in.; pp. 38; 31 text figures. Address the author.

MAGAZINES AND THAW HOUSES FOR EXPLOSIVES—By Clarence Hall and Spencer P. Howell. Technical Paper 18, Department of the Interior, Bureau of Mines; Joseph A. Holmes, Director. Washington, D. C.: Pub. Doc. Paper; 5¾x9 in.; pp. 34; illustrated.

MICA—Its Occurrence, Exploitation, and Uses. By Hugh S. deSchmid, M. E. Second edition. Ottawa: Pub. Doc. No. 118, Mines Branch, Canada Department of Mines; Hon. W. Templeman, Minister. Stiff paper; 6¾x10 in.; pp. 411; 38 plates; 22 maps; 67 text figures.

THE MINING DISTRICTS OF THE WESTERN STATES—By James M. Hill. With a Geologic Introduction by Waldemar Lindgren. Bulletin 507, U. S. Geological Survey; Geo. Otis Smith, Director. Washington, D. C.: Pub. Doc. Paper; 5¾x9 in.; pp. 309; 17 maps.

MINING OPERATIONS FOR GOLD, COAL, ETC., PROVINCE OF BRITISH COLUMBIA—Report of the Minister of Mines, 1911. (William Fleet Robertson, Provincial Mineralogist, Bureau of Mines.) Victoria, B. C.: Pub. Doc. Paper; 7¼x10½ in.; pp. 313; plates and maps.

NATIONAL BOARD OF FIRE UNDERWRITERS—Reports of Committee on Fire Prevention. No. 202: On the City of Akron, Ohio. No. 203: On the City of Hannibal, Mo. No. 204: On the City of Chicago Heights, Ill. New York: The Board (135 William St.) Paper; 8¼x10¾; pp. 23, 6, 9, respectively; illustrated.

THE NEED FOR A NATIONAL BUDGET—Report of the Commission on Economy and Efficiency, with Message from the President of the United States. Washington, D. C.: Government No. 851, 62d Congress, 2d Session, House of Representatives. Cloth; 6x9½ in.; pp. 568.

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